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REPORT TO THE SECOND SESSION OF THE CONFERENCE IN THE MATTER OF POLLUTION OF THE SOUTH PLATTE RIVER BASIN

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
DENVER, COLORADO

27 APRIL 1966

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PB 260 315

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
South Platte River Basin Project

April 27, 1966

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Pollution problems and solutions in two geographic areas--the Denver Metropolitan Area and the Middle and Lower Basin of the South Platte River and its major tributaries from Brighton to the Colorado-Nebraska border--are discussed. In the Denver area, information is presented on the sources of pollution and the effects of these waste loads on the area's streams, and recommendations for pollution abatement are given. The second section discusses Barr Lake pollution problems, wastes from feedlot operations within the basin, and waste discharges from been sugar mills. Recommendations to deal with these problems are presented.

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REPORT TO THE
SECOND SESSION OF THE CONFERENCE
IN THE MATTER OF POLLUTION OF THE
SOUTH PLATTE RIVER BASIN

April 27, 1966

Page 13, Section I, Item 4 -- "Permit no discharge of phenol-like substances in concentrations greater than 25 milligrams per liter." -- Should read, "Permit no discharge of phenol-like substances in concentrations greater than 25 parts per billion."

Page 16, Section I, Subsection A, Item 5 -- "The Denver Union Stockyards shall alter present livestock drinking water overflow and pen drains to prevent discharge of livestock excreta and feed to the South Platte River." -- Should read, "The Denver Union Stockyards shall alter present livestock drinking water overflow and pen drains to prevent discharge of livestock excreta and feed to the South Platte River on or before January 1, 1967."

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SECOND SESSION OF THE CONFERENCE
IN THE MATTER OF POLLUTION OF THE
SOUTH PLATTE RIVER BASIN

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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April 27, 1966

TABLE OF CONTENTS

Page

List of Figures ii

INTRODUCTION 1

SUMMARY AND CONCLUSIONS 9

RECOMMENDATIONS
- Denver Metropolitan Area 13
- Feedlots 18
- Sugar Beet Processing Mills 20
- Flow Augmentation for Water Quality Control 22

DENVER METROPOLITAN AREA 24
- General 25
- Sources of Waste 26
  - Municipal Waste Discharges 26
  - Industrial Waste Discharges 29
  - Metropolitan Denver Sewage Disposal District No. 1 33
- Effects on Streams - Denver Metropolitan Area 37
  - Bear Creek 38
  - Cherry Creek 39
  - Clear Creek 40
  - Sand Creek 43
  - South Platte River-From Littleton through Dnever 45
  - South Platte River-Below Denver 48
- Ground Water Studies 54
- Municipal Water Supplies 59

MIDDLE AND LOWER BASIN 63
- Barr Lake 63
- Insect Vector Problems 66
- Feedlot Waste 68
- Sugar Beet Processing Wastes 71
  - St. Vrain Creek 72
  - Big Thompson River 74
  - Cache la Poudre River 76
  - South Platte River-Brighton to Kuner, Colorado 79
  - South Platte River-Fort Morgan to the Stateline 82

APPENDICES
- Appendix A - Project Sampling Data, Denver Metropolitan Area 1-14
- Appendix B - Project Report, Meat Industry Wastes, Denver Metropolitan Area 1-14

LIST OF FIGURES

Number	Title	Following Page
1	General Map - South Platte River Basin	8
2	Significant Waste Loads, Denver Metropolitan Area, PE for BOD	32
3	Significant Waste Loads, Denver Metropolitan Area, PE for TSS	32
4	Metropolitan Denver Sewage Disposal District Number 1	34
5	Populations of Bottom Organisms - Bear Creek	40
6	Sludgeworms in Cherry Creek	40
7	Clear Creek Water Quality	42
8	Sand Creek Water Quality	44
9	Quality of SPR--Denver Metro Area - August 1964	46
10	Quality of SPR--Denver Metro Area - December 1964-March 1965	48
11	Quality of SPR--Denver to Big Thompson River	50
12	Quality of SPR--Denver to Greeley	52
13	Population of Bottom Organisms Littleton to Platteville	52
14	ABS in Valley-Fill Aquifers - Denver Metro Area	56
15	Nitrate in Valley-Fill Aquifers - Denver Metro Area	56
16	Sources of Public Water Supply - Denver Metro Area	62
17	Locations of Public Water Supply, Shallow Well Fields, and Sewage Treatment Plants - Denver Metro Area	62
18	Quality of St. Vrain Creek	72

List of Figures (Continued)

Number	Title	Following Page
19	Quality of Big Thompson & Little Thompson Rivers	74
20	Quality of Cache la Poudre River	78
21	Quality of SPR - Brighton to Kuner	80
22	Quality of SPR - Fort Morgan to Stateline	84
23	Algal Changes - SPR - Sterling to Ovid	88
24	Photograph - Waste Effluent, Longmont Sugar Beet Mill	88
25	Photograph - Crayfish - SPR - Kersey	88
26	Bottom Animals - SPR - Sterling	90
27	Photograph - Sugar Beet Wastes, St. Vrain Creek	90
28	Present - 5-day BOD Stream Values - SPRB	98
29	1972 - 5-day BOD Stream Values - SPRB	98
30	2000 - 5-day BOD Stream Values - SPRB	98

INTRODUCTION

The First Session of the Conference in the Matter of Pollution of the South Platte River Basin (Colorado) was called by the Secretary of Health, Education, and Welfare, at the request of Governor John A. Love. The Conference was held in Denver, Colorado on October 29, 1963. At that time the critical water pollution problems in the Basin were outlined. As a result of that Conference, the South Platte River Basin Project was created, first as a technical arm of the U. S. Public Health Service, and now under the direction of the Federal Water Pollution Control Administration. The primary responsibility given the Project was to cooperate with the State of Colorado in developing plans for the control and abatement of water pollution in the South Platte River Basin.

Specifically, the Project was instructed to:

1. Determine the legitimate water uses and locate the sources of pollution having an adverse effect on those uses.
2. Through field investigations determine the physical, chemical, and biological responses of the River to pollution and evaluate the previously located sources of pollution with respect to the conditions in the River.
3. Compute the waste load reductions necessary to obtain desired water quality and recommend the water quality control measures needed to effect the desired waste load reductions.

The Project reached its full manpower strength of approximately 23 people in mid-1964, consisting of engineering and associated professional and administrative personnel. The Project has been operating since that time on a budget of about $230,000-250,000 annually. Project offices are located in the Federal Office Building, 19th and Stout Streets, in downtown Denver, and the Project Laboratory is housed in the Colorado State Department of Public Health building.

This report covers, in whole or in part, essentially two geographical areas. The first area is referred to as the Denver Metropolitan Area and covers that area bounded by the City of Brighton to the north, the City of Aurora and Cherry Creek Reservoir to the east, the Municipality of Littleton to the south, and the Town of Evergreen and the City of Golden to the west.

The second geographical area is designated as the Middle and Lower Basin and encompasses the South Platte River from the City of Brighton to the Colorado-Nebraska Stateline, St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River, all major tributaries to the South Platte River.

The first major section of the report is based upon Project investigations in the Denver Metropolitan Area. This section of the report contains information regarding the sources of pollution that have been located and studied, and effects of these waste loads on the streams in the area. In addition, it includes findings concerning the relationships between surface waste disposal and pollution of the ground water. In brief, the Project studies indicate that as a result of municipal and industrial waste disposal in the Denver Metropolitan Area, the waters in most of the South Platte River and its tributaries are grossly polluted, and, further, significant contamination exists in portions of the ground-water aquifer. This degradation interferes with the legitimate and beneficial uses of the River for a considerable distance below the Denver Metropolitan Area. General and specific recommendations for pollution abatement have been prepared and are presented, together with appropriate time schedules for the Denver Metropolitan Area.

The second major section of this report describes the Project study relating to the Barr Lake odor problem, including a projection of future conditions in the Lake after operation of the Metropolitan Denver Sewage Disposal District Number 1 treatment facilities are begun. Significant problems concerning the transmission of disease by mosquitoes, rats, and flies within the Basin are presented as these vectors relate to present organic pollution. A summary of wastes associated with feedlot operations throughout the Basin are discussed and recommendations proposed. A detailed report relating to waste discharges from ten operating beet sugar mills and the effects of these discharges on the streams in the Middle and Lower Basins is presented. Project studies confirm that gross pollution occurs in the streams below the beet sugar mills during the operating season resulting in interference with the legitimate and beneficial uses of the River and its tributaries. Specific recommendations for pollution abatement by the beet sugar industry, together with appropriate time schedules are presented.

The principal present and future uses of the waters of the South Platte River Basin are: 1) municipal water supply; 2) industrial water supply; 3) agriculture; 4) recreation, including water-contact sports; 5) establishment of fish and aquatic life; 6) preservation of wild life; and 7) aesthetic enjoyment. It is realized that the agricultural needs, principally for irrigation, require and use the greatest amounts of water at this time; however, turning to the future of the South Platte Valley, with the resultant expanding population, the influx of industry, and the demand by residents and visitors alike for adequate recreational facilities, the pattern of past use is already changing. To provide for current and prepare for future needs for water, the establishment of a warm-water fishery is proposed throughout the South Platte River and its tributaries as a minimum standard to protect the Basin water uses for the benefit of all the citizens.

To protect and preserve the waters of the South Platte River and its tributaries within the State of Colorado for present and future legitimate and beneficial water users, the following water quality objectives have been developed:

1. In the main-stem South Platte River from just above the City of Littleton to the discharge of Metropolitan Denver Sewage Disposal District No. 1 treatment facility; in Bear Creek from the Town of Evergreen to its mouth; and in Cherry Creek from the Cherry Creek Reservoir to its mouth --
    a. The dissolved oxygen (DO) content be maintained at not less than 5 mg/1;
    b. The 5-day 20^{o}C BOD level not be allowed to exceed 10 mg/1, and;

c. The total and fecal coliform levels not exceed 2400 and 500 coliform bacteria per 100 ml, respectively.

2. In the main-stem South Platte River from just below the discharge of Metropolitan Denver Sewage Disposal District No. 1 treatment facilities to just above the discharge from the Great Western Sugar Company in the City of Brighton; all of Sand Creek, and in Clear Creek from the City of Golden to its mouth --

   a. The dissolved oxygen (DO) content be maintained at not less than 4 mg/l;

   b. The 5-day, 20°C BOD level not be allowed to exceed 20 mg/l, and;

   c. The total and fecal coliform levels not exceed 5000 and 1000 coliform bacteria per 100 ml, respectively.

3. In the main-stem South Platte River from just below the discharge from the Great Western Sugar Company mill in the City of Brighton to the Colorado-Nebraska Stateline; in the St. Vrain Creek from Longmont to its mouth; in the Big Thompson River from Loveland to its mouth; in the Little Thompson River from Johnstown to the stream mouth; and in the Cache la Poudre River from Windsor to the stream mouth --

   a. The dissolved oxygen (DO) content be maintained at not less than 4 mg/l;

   b. The 5-day, 20°C BOD level not be allowed to exceed 15 mg/l, and;

   c. The total and fecal coliform levels not exceed 5000 and 1000 coliform bacteria per 100 ml, respectively.

Based upon these water quality control objectives, specific abatement measures must be provided by those industrial firms and municipalities and districts which discharge wastes to the Basin streams. It is clear, however, that treatment of wastes alone cannot, at all times provide the water quality that is necessary. The withdrawals from the streams for irrigation, particularly during periods of critical low flow, in many instances, does not permit sufficient water to provide the necessary dilution of waste discharges. Therefore, flow augmentation in addition to an effective waste abatement program is necessary and vital in the future to achieve satisfactory water quality in the streams.

The Federal Water Pollution Control Act provides in Section 3(b)(1) "In the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other Federal agency, consideration shall be given to inclusion of storage for regulation of streamflow for the purpose of water quality control, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source."

It has been determined that minimum streamflows of 25 cfs will be needed in the main-stem South Platte River throughout the entire year and at all locations from a point upstream of Littleton down to the Colorado-Nebraska Stateline. Augmentation flows for the upper and middle areas of the South Platte River must be made available in the future from either the proposed Chatfield or Two Forks Project above Denver. This fact was brought to the attention of the U. S. Corps of Engineers at Omaha, Nebraska in November 1965 in an official letter citing the need for storage for streamflow augmentation from Chatfield Reservoir.

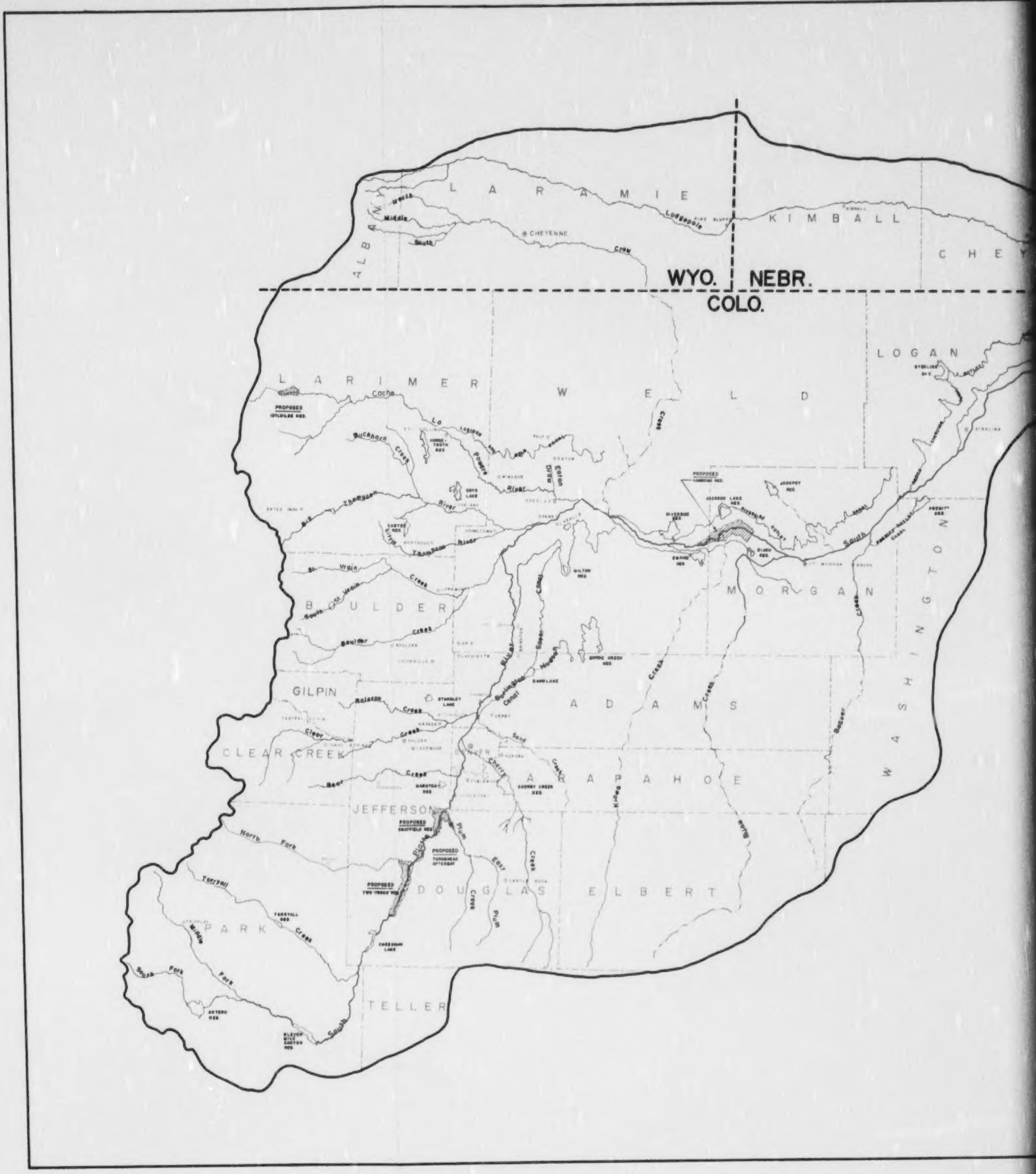
In the middle and lower portions of the South Platte River the necessary augmentation flow can be made available directly from the proposed Narrows Project and from exchange of water obtained from a number of sources. The need for storage for low flow augmentation in the proposed Narrows Project was outlined in an official letter to the U. S. Bureau of Reclamation, Denver, in December 1965.

Similarly, flow augmentation for St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River is also necessary to attain adequate water quality throughout these streams in conjunction with an effective waste abatement program. Minimum streamflows of 15 cfs have been determined to be necessary for each of these three streams. The same basic principles apply in these streams as outlined for the main-stem South Platte River except that a source of water supply is not as readily available in this case.

These necessary flows can be made available for water quality control purposes from appropriate storage reservoirs when they are constructed. Such sources would involve projects proposed in the future, or may even involve the purchase of existing water rights by the State.

Maximum flow augmentation requirements on the main-stem South Platte River are equal to 18,000 acre-feet per year, but the availability of high flow and some minimum flow already present in the system at virtually all times, could reduce required augmentation to about 10,000 acre-feet for the average year. Maximum flow augmentation on each of the tributary streams equals 11,000 acre-feet per year, but in actual practice this need in the average year would probably be reduced to about 6,000 acre-feet.

An important concept is that these flows remain in the stream only when a critical need arises; and if a critical need does not exist downstream, these flows may be used for other purposes. Also, flow augmentation is not needed when the streamflow is equal to, or greater than 25 cfs throughout the circuit.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NEBR.
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GILPIN
ADAMS
CLEAR CREEK
DENVER
ARAPAHOE
JEFFERSON
DOUGLAS
ELBERT
PARK
TELLER
North
Middle
South
CHEYENNE
Crow
Lodgepole
PINE BLUFFS
KIMBALL
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CARTER RES
ESTES PARK
Drum
Eaton
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St.
Vrain
Creek
South St. Vrain
Boulder
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BOULDER
LOUISVILLE
Ralston
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STANDLEY LAKE
ARVADA
Clear
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GOLDEN
Bear
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MARSTON RES
Burlington
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Beebe
Seep
Canal
Hudson
BARR LAKE
MILTON RES
HORSE CREEK RES
Sand
Cherry
Creek
CHERRY CREEK RES
Kiowa
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Bijou
Creek
Beaver
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PROPOSED
CHATFIELD RES
PROPOSED
TWO FORKS RES
PROPOSED
TUCKSHEAD AFTERBAY
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Creek
CASTLE ROCK
Platte
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Tarryall
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TARRYALL RES
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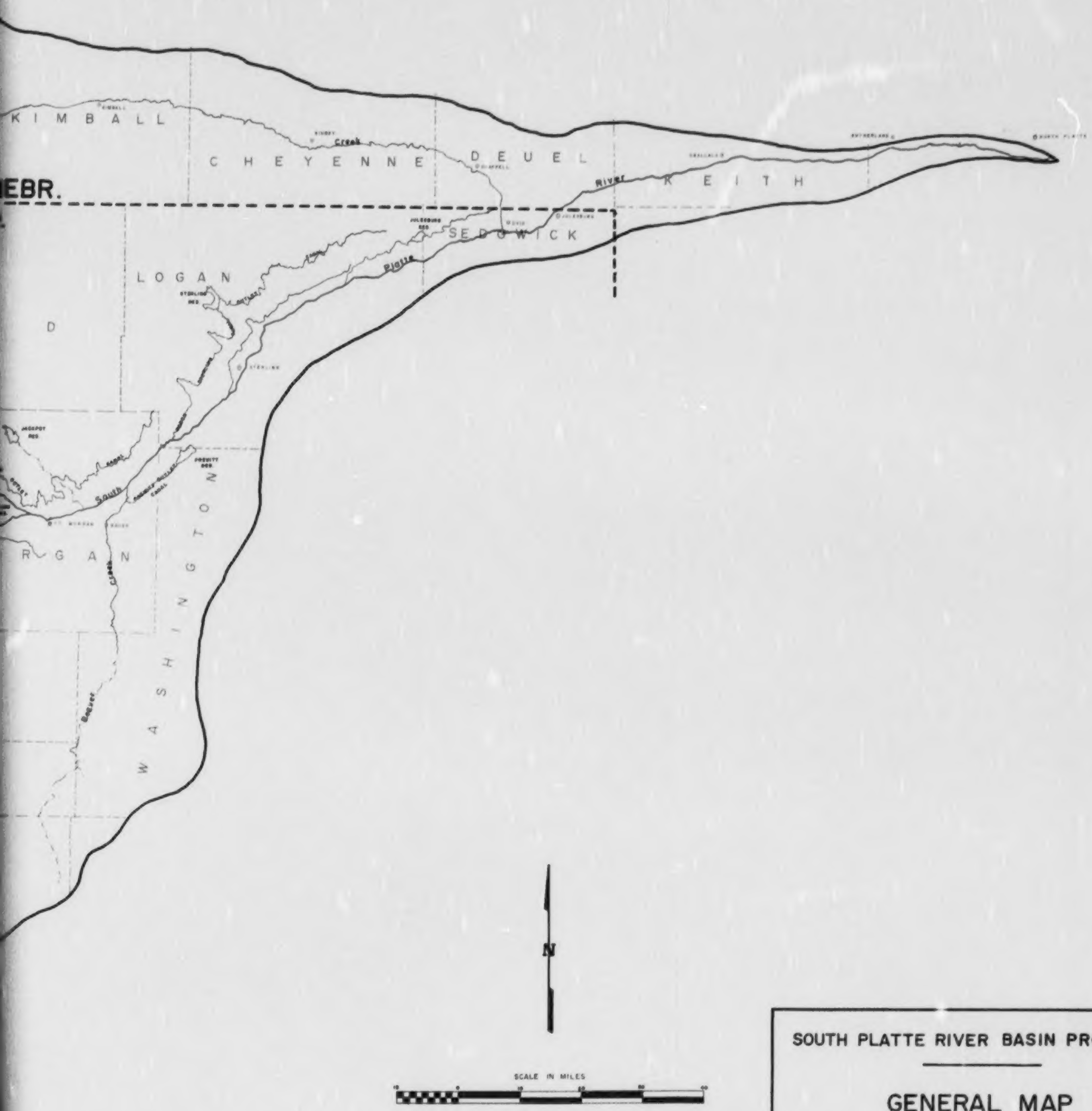
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FEBRUARY 1964
REVISED MARCH 1966

SOUTH PLATTE RIVER BASIN PROJECT

GENERAL MAP

DEPT. OF HEALTH, EDUCATION, & WELFARE
Water Pollution Control Administration
REGION VIII DENVER, COLO.

FIGURE I

SUMMARY AND CONCLUSIONS

The South Platte River originates on the east side of the Continental Divide in central Colorado, flows northeast across the State of Colorado into Nebraska where it joins the North Platte River to form the Platte, a tributary of the Missouri River. Its total drainage area is approximately 24,300 square miles, of which 19,450 square miles are within the State of Colorado.

The principal present water uses in the South Platte River Basin are agricultural, irrigation, and industrial water supply. If water quality is considerably improved, the waters of the South Platte River can be used for municipal water supply, recreation, including water-contact sports, establishment of a warm-water fishery and the necessary aquatic life to support fish, wildlife preservation, and aesthetic enjoyment, in addition to the present agricultural, irrigation, and industrial uses.

The pattern of water use is expected to change from agriculture to higher uses with the expanding population, the influx of industry, and the demand by both residents and visitors for adequate recreational facilities.

Based on the present interferences with water uses resulting from discharges of untreated and inadequately treated municipal and industrial wastes and the future needs of the area, specific pollution abatement measures must be provided. However, a high degree of treatment of wastes alone cannot at all times provide the water quality that is necessary to support these legitimate and beneficial uses. The withdrawals from the streams for irrigation, particularly during periods of low flow, in many instances does not permit sufficient water in the streams to provide the necessary dilution of treated waste effluent. An effective waste abatement program, together with flow augmentation, is necessary to achieve satisfactory water quality in the South Platte River Basin.

The Metropolitan Denver area covers that area bounded by the City of Brighton to the north, the City of Aurora and Cherry Creek Reservoir to the east, the Municipality of Littleton to the south, and the Town of Evergreen and the City of Golden to the west.

As a result of discharges of raw and inadequately treated wastes in the Denver Metropolitan area, the waters of the South Platte River and its tributaries in and below this area are grossly polluted and significant contamination exists in portions of the shallow ground-water aquifer.

Five municipal treatment plants serving 70 percent of the sewered population provide only primary treatment. Eight of the remaining 21 sewage treatment works are receiving loads greater than their design capabilities. Further, 18 of these municipal sewage treatment plants either have no facilities for disinfection of wastes or are not adequately utilizing the existing facilities.

There are many types of industry located in the Denver Metropolitan area. Seventy-five percent of the industrial waste loading in Denver is discharged to municipal treatment plants. Most of the remaining industrial wastes are discharged without proper treatment to the streams through storm sewers or individual outfalls.

Both the sewage and industrial waste discharges to the South Platte River and its tributaries in the Denver Metropolitan area contain a variety of obnoxious constituents which damage water quality and restrict its use for most legitimate and beneficial purposes. These effects persist a considerable distance below Denver.

Project findings show that: 1) coliform densities greatly exceed all commonly accepted standards for recreational use in almost all reaches of the South Platte River and its tributaries and presents a health hazard to those persons coming in contact with the waters; 2) oxygen demanding wastes have caused low dissolved oxygen levels in many reaches of the South Platte River below Denver, causing near septic conditions in the stream; 3) suspended and settleable solids form sludge deposits in the River which have destroyed desirable aquatic plants and animals and create sight and odor nuisance conditions which preclude use or development of riverside recreational areas; and 4) pollution of the South Platte River has affected ground-water supplies and has thus created a hazard to health.

The Middle and Lower Basin area encompasses the South Platte River from the City of Brighton to the Colorado-Nebraska Stateline and its tributaries, St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River.

Pollution in this area from municipal and industrial wastes has caused significant problems. As a result of municipal and industrial waste effluents reaching Barr Lake, extreme odor nuisance conditions have been reported in the spring and fall of the year. Feedlot operations contribute high bacterial concentrations to the waters in the South Platte River Basin and have created sight and odor nuisances along banks of the streams.

Organic pollution of the South Platte River and its tributaries has created conditions ideal for the breeding of mosquitoes, rats, and flies which can transmit diseases to humans such as the plague, encephalitis, and a wide range of enteric diseases.

Wastes from the beet sugar processing industry contribute heavily to the gross pollution of the Middle and Lower South Platte River Basin. This pollution interferes with most legitimate and beneficial uses of the River and its tributaries.

Municipal and industrial wastes discharged to the waters of the South Platte River and its tributaries within the State of Colorado endanger the health or welfare of persons in Colorado. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

A program of surveillance of the Basin waters is necessary in order to provide the data required for constant evaluation and insure the highest possible benefits consistent with future legitimate and beneficial water uses.

In order that the allowable water quality objectives not be exceeded, specific recommendations and time schedules have been developed for individual sources of waste in the Denver Metropolitan area and in the Middle and Lower Basin areas for feedlot operations and the beet sugar industry. Specific recommendations have not yet been developed for the remaining municipal and industrial wastes in the Middle and Lower Basin areas, but will be made within the next nine months. Consistent with the allowable water quality objectives, it is expected that these municipalities and industries will be required to treat their raw wastes with an efficiency in the area of 90 percent.

RECOMMENDATIONS

I. Denver Metropolitan Area

To insure that the allowable water quality objectives are not exceeded and effective reduction in present levels of pollution are obtained, it will be necessary to subject all wastes discharged to Basin streams in the Denver Metropolitan area to a minimum of secondary treatment and provide a high degree of operating efficiency in the waste treatment processes. Adequate treatment is defined as that which will:

1. Remove at least 90 percent of the BOD and total suspended solids (TSS) and all of the settleable solids.
2. Provide disinfection facilities equivalent to that which will insure a chlorine residual of not less than 1.0 milligram per liter in the plant effluent after a detention period of at least 20 minutes.
3. Remove essentially all toxic materials.
4. Permit no discharge of phenol-like substances in concentrations greater than 25 milligrams per liter.
5. Permit no visible floating oil or grease in the streams.

A. Specific

Municipal

1. The following plants shall divert all sewage to the Metropolitan Denver Sewage Disposal District No. 1 on or before January 1, 1967:

a. City of Arvada
b. Baker Sanitation District
c. Clear Creek Valley Sanitation District
d. City of Denver (Northside)
e. City of Denver (Eastside)
f. Federal Correctional Institution
g. Fruitdale Sanitation District
h. North Washington Sanitation District
i. N. W. Lakewood Sanitation District
j. City of Thornton
k. City of Westminster
l. City of Wheatridge

2. The following plants shall continue to provide adequate treatment for removal of BOD, settleable solids and bacteria and, in addition provide for 90 percent removal of TSS of all sewage discharged to the Basin streams on or before January 1, 1967:

   a. City of Aurora (Sand)
   b. City of Brighton
   c. Fitzsimons Army Hospital
   d. South Adams Sanitation District

3. The following plants shall provide adequate treatment, including disinfection of all sewage discharged to Basin streams. Plans shall be submitted to the State Water Pollution Control Agency on or before January 1, 1967 and additional facilities shall be in operation before January 1, 1968:

   a. City of Aurora (Westerly)
   b. City of Evergreen
   c. City of Littleton
   d. South Lakewood Sanitation District

4. The following plants shall provide adequate treatment, including disinfection of all sewage discharged to Basin streams, on or before January 1, 1967:

   a. Buckley Air Station
   b. City of Englewood

5. The City of Golden (Adolph Coors Company) shall continue to provide adequate treatment for removal of BOD, settleable solids and TSS, and in addition provide for adequate disinfection of all sewage discharged to Basin streams on or before January 1, 1967.

6. The Metro District plant (presently under construction--to be in operation prior to January 1, 1967) shall provide at least 92 percent removal of BOD and total suspended solids and remove all of the settleable solids in addition to other criteria for adequate treatment on or before January 1, 1967.

Industrial

1. The following industries shall divert present waste discharges from the South Platte River to the sanitary sewer on or before January 1, 1967:

   a. Armour Company
   b. Capitol Rendering Company
   c. Chicago, Burlington & Quincy Railroad
   d. Colorado and Southern Railroad
   e. Denver & Rio Grande Railroad
   f. Gates Rubber Company
   g. Kuner Empson Canning Company (Brighton)
   h. Litvak Packing Company
   i. United Fryer Stillman
   j. Samsonite Corporation

2. The Colorado School of Mines Research Foundation shall provide sufficient capacity for the retention pond to prevent overflow to Clear Creek on or before January 1, 1967.

3. The Coors Porcelain Company shall divert floor drain waste discharges from Clear Creek to the sanitary sewer on or before January 1, 1967.

4. The following industries shall provide adequate treatment to further reduce concentration of phenol to Basin streams on or before June 1, 1967:

    a. Continental Oil Company
    b. Empire Oil Company
    c. Tenneco Oil Company

    In addition, the Continental Oil Company shall provide adequate treatment to remove chromium from their final waste discharges on or before June 1, 1967.

5. The Denver Union Stockyards shall alter present livestock drinking water overflow and pen drains to prevent discharge of livestock excreta and feed to the South Platte River.

6. The Gates Cyclo shall provide adequate treatment including disinfection prior to discharge to the South Platte River or any Basin waterway. Plans shall be submitted to the State Water Pollution Control Agency on or before January 1, 1967, and treatment facilities shall be in operation before January 1, 1968.

7. The Public Service Company of Colorado shall provide adequate treatment to obtain further reduction of TSS from the fly ash lagoon at the Zuni plant and divert the overflow and backwash discharge from the softening process at the Zuni plant to the sanitary sewer on or before January 1, 1967.

8. The Stapleton Airfield shall divert present industrial waste discharges from Sand Creek to the sanitary sewer on or before January 1, 1967.

B. General

1. All industrial and commercial establishments in the Denver Metropolitan area presently discharging raw or inadequately treated wastes to Basin streams via storm sewers and miscellaneous outfalls and not specifically named in part "A" of the Recommendations, be investigated by municipal, county or State authorities and the wastes diverted to the sanitary sewers prior to January 1, 1967.
2. In those cases where concentrations of certain wastes, such as paunch contents, grease, oil, and toxic materials are not acceptable to municipal sewage treatment plants, satisfactory in-plant treatment facilities shall be provided. Facilities for such in-plant treatment shall be in operation by January 1, 1967.
3. In those cases where use of the sanitary sewer system is considered to be unreasonable by the State Water Pollution Control Agency, adequate secondary treatment of wastes must be provided. Plans shall be submitted to the State Water Pollution Control Agency on or before January 1, 1967 and the facilities placed in operation on or before January 1, 1968.

C. Other

1. All waste settling ponds shall be provided with a seal of an impermeable material to prevent pollution of the valley-fill aquifer.

2. A ground-water monitoring program be established and carried out by the State and/or local health authorities in areas affected by excessive nitrate and ABS.
3. An appropriate State Agency be empowered to approve or disapprove sources of supply and treatment facilities for municipal water systems.
4. All sources of public water supply be subject to effective disinfection by chlorination or other approved methods with provision for adequate detention and duplicate feeding devices.
5. An appropriate State Agency be empowered to approve or disapprove plans for municipal and industrial treatment facilities prior to construction.
6. The staffs of the appropriate State Agencies be increased to provide the necessary supervision and technical advice for carrying out an effective water supply and pollution control program.
7. A program of surveillance of the Basin waters must be undertaken by the appropriate State Agency to obtain the data required for constant evaluation and insure the highest possible benefits consistent with future legitimate and beneficial water uses.

II. Feedlots

To achieve an ultimate solution, feedlot operations should be relocated away from urban and suburban populations and streams; however as an interim measure, it is recommended that:

A. The four feedlots which pump or pipe waste drainage to the surface streams:

1. The Monfort Feedlot in Greeley
2. The Farr Farms Feedlot in Greeley
3. The Weisbart Feedlot in Brush
4. The Mancini Feedlot in Brighton

shall initiate plans to design and construct adequate treatment facilities such as the use of lined lagoons, or treat these wastes by equivalent means to prevent the pollution of both surface and ground-water resources.

B. The seven feedlots which have overland drainage to surface streams:

1. The Western Beef Feedlot in Denver
2. The Farr Farms Feedlot in Greeley
3. The Mancini Feedlot in Brighton
4. The National Food Company Feedlot in Brighton
5. The Mountain View Angus Ranch Feedlot in Platteville
6. The Ludlow Cattle Company Feedlot in Longmont
7. The Tittle Feedlot north of Greeley

shall initiate plans to design and construct berms or suitable drainage facilities to divert the surface runoff to lined lagoons or treat these wastes by equivalent means to protect against the pollution of both surface and ground waters.

C. Waste abatement requirements for these nine feedlots are to be developed before January 1, 1967 by the State Water Pollution Control Agency. Overall planning should be coordinated with the South Platte River Basin Project. Necessary feedlot waste handling and treatment facilities shall be constructed before January 1, 1968.

D. All feedlots in the South Platte River Basin shall initiate a program for frequent removal of manure and other waste material in the feedlots. Efforts shall be made by the industry to reduce odor to a minimum. The feedlot program shall be regulated by the State Water Pollution Control Agency.

III. Sugar Beet Processing Mills

The following pollution abatement schedule applies to the Middle and Lower Basin areas. This includes the main-stem South Platte River from Brighton to the Colorado-Nebraska stateline, St. Vrain Creek from Longmont to the stream mouth, the Big Thompson River from Loveland to the stream mouth, the Little Thompson River from Johnstown to its mouth, and the Cache la Poudre River from Windsor to its mouth.

It is recommended that:

A. The sugar beet industry provide treatment of wastes so that the total 5-day BOD load discharged in any given day in the total effluents entering Basin streams or waterways shall not exceed the values given below for the respective plants. Residual wastes may be discharged over an extended period of the year if necessary.

Brighton -- 1100 pounds 5-day BOD per day

Longmont -- 1450 pounds 5-day BOD per day

Loveland -- 1750 pounds 5-day BOD per day

Johnstown -- 800 pounds 5-day BOD per day

Windsor -- 1100 pounds 5-day BOD per day

Eaton -- 1000 pounds 5-day BOD per day

Greeley -- 1100 pounds 5-day BOD per day

Fort Morgan -- 3000 pounds 5-day BOD per day

Sterling -- 2200 pounds 5-day BOD per day

Ovid -- 2800 pounds 5-day BOD per day

B. There be no settleable solids contained in the total effluents, and that suspended solids loads in these effluents not exceed the numerical levels prescribed above for 5-day BOD.

C. Disinfection be provided for each waste discharge so that the receiving stream or waterway directly below each mill shall not show an increase of more than 5,000 total coliform bacteria per 100 ml, and 1,000 fecal coliform per 100 ml, over the corresponding densities upstream of the mill discharge.

D. Dissolved oxygen in the treated waste effluents not be less than 2 milligrams per liter at any time to insure minimum dissolved concentrations of 4.0 mg/l in the receiving streams or waterways.

E. There be absence of grease, oil, floating solids, slime or sludge banks in the receiving streams, or waterways, as a result of waste discharges from the sugar beet mill.

F. Waste treatment and control measures and other procedures shall not cause pollution of the underlying valley-fill aquifers.

G. There be no disagreeable odors or other nuisance in the areas outside of, and immediately adjacent to, the plant sites.

H. Each sugar beet mill shall conduct continuous monitoring of the quality of final waste effluents and of each receiving stream above and below the points of waste discharge to these streams. Adequate records shall be maintained by each plant on water quality and shall be reported regularly to the State Water Pollution Control Agency.

I. The waste abatement measures given above for the sugar beet industry in the South Platte River Basin shall be completed by September 30, 1968 to provide full capacity for total plant wastes in the 1968-69 campaign and all subsequent campaigns.

J. Final approval of design plans on all waste treatment and control measures, inspection during and following construction of facilities, and final joint evaluation (together with the industry) of waste treatment and control performance shall be provided by the State Water Pollution Control Agency.

IV. Flow Augmentation for Water Quality Control

Since available streamflows under present water use patterns are not sufficient to guarantee adequate water quality for all future uses, even with the recommended waste abatement program in effect, flow augmentation is necessary. It is estimated that flow augmentation in the order of 10,000 to 18,000 acre-feet per year is needed on the main-stem of the South Platte River, and 6,000 to 11,000 acre-feet per year each on St. Vrain Creek, the Big Thompson and the Cache la Poudre Rivers.

The pollution abatement schedule assumes that quantities of surface water, including reservoir flows, presently used by sugar beet mills in processing, will not change significantly in the future.

It is recommended that:

A. Minimum streamflows of 25 cfs be maintained on the mainstem South Platte River throughout the entire year and at all locations, from upstream of Littleton down to the Colorado-Nebraska Stateline.

B. Minimum streamflows of 15 cfs be maintained on St. Vrain Creek from above Longmont downstream, on the Big Thompson River from above Loveland downstream, and on the Cache la Poudre River from above Windsor downstream, throughout the entire year and at all locations within the designated areas.

DENVER METROPOLITAN AREA

The City of Denver, Capitol of Colorado, is located in the north central portion of the State on the western edge of the Great Plains, approximately 50 miles east of the Continental Divide. The County of Denver has identical boundaries with the City, and both are considered as a single unit in a political as well as a geographical sense. In addition to Denver, the Metropolitan area includes portions of Adams, Arapahoe, Boulder, and Jefferson Counties. According to estimates obtained from the State Commerce and Development Division, as of July 1, 1964 the population in the City and County of Denver was 525,000 persons, while approximately 1,000,000 persons resided in the Metropolitan area. The Metropolitan area represents 6.7 percent of the area of the entire State, and includes about 700 square miles. Approximately one-half of the total population of the State is located within these confines.

Industrial activity within the Denver Metropolitan area is characterized by diversification since Denver serves as a focal point for manufacturing, transportation, and food processing. It is estimated that one-half of all industrial plants in Colorado are located within the Denver Metropolitan area. Among these are Martin Denver, missile manufacturers (7,000-12,000 employees); Gates Rubber Company (5,400 employees); Samsonite Corporation, luggage manufacturers, (1,800 employees); and Adolph Coors, brewery, (1,100 employees). Three petroleum refineries in the Denver Metropolitan area process an average of 35,000 barrels daily. Four major railroads, the Chicago, Burlington & Quincy; Colorado and

Southern; the Denver and Rio Grande; and Union Pacific operate extensive repair and maintenance facilities in Denver. Denver was considered the fourth largest meat-packing area in the United States in 1963.

General

The definition of certain technical terms used in this report is given as follows:

Biochemical oxygen demand abbreviated as BOD and analyzed as 5-day 20°C BOD is a measure of the oxygen demand of sewage and industrial wastes. BOD in the stream is a measure of oxygen used by living organisms in decomposing these wastes. Total suspended solids are solids found in waste water or in the stream, which can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt from erosion. Population equivalents describe the pollutional effect of various waste discharges in terms of a corresponding effect of discharging raw sewage from an equivalent number of human population. Each P.E. represents the waste contributed by one person in a single day. Primary treatment is the removal of settleable solids from sewage and industrial wastes. Units of a primary sewage treatment plant consist of screens, grit removal chambers, settling tanks, sludge digestors and sludge drying beds and may include chlorination facilities. Primary treatment plants generally remove 25 to 35 percent of the BOD and 45 to 65 percent of the total suspended matter. In secondary treatment plants primary treatment is followed by biological methods to remove additional organic wastes. Units of a secondary treatment plant comprise in addition to primary treatment, trickling filters or activated sludge basins, final settling of wastes, and should include chlorination facilities. Secondary treatment plants generally remove from wastes 80 to 95 percent of the BOD and suspended matter. In this report, all data in the presentation are average or mean values except for bacterial densities. Bacteria are represented by median values obtained from the collected data.

Sources of Waste

Municipal Waste Discharges - During the period from January 1964 to December 1965 various Project investigations were conducted in the Denver Metropolitan area to locate and evaluate the sources of waste discharge to Basin streams. There are about 100 separate agencies directly involved in the collection and/or treatment of municipal sewage in the Metropolitan area. Treatment facilities are provided by 7 sanitary districts, 14 municipalities and 5 institutions. The major treatment works is the Denver Northside plant, with an average flow of about 72 million gallons per day (MGD), serving an estimated 600,000 persons. The remaining 25 sewage treatment plants serve about 354,000 persons. On the basis of these data, municipal wastes for about 95 percent of the population of the Metropolitan area receive treatment at these 26 plants and the remainder of the population, or 46,000 persons is served by septic tanks or similar facilities. It is estimated that 40 percent of overall loading to Metropolitan area sewage treatment plants are from industrial operations. Industrial waste loading is particularly significant at the Clear Creek Valley District, Denver Northside, Golden (Adolph Coors Company), and North Washington District sewage treatment plants.

Project investigations show the overall reduction of 5-day, 20°C BOD to be about 50 percent, while the overall reduction of total suspended solids is about 75 percent. Five municipal sewage treatment plants serving about 70 percent of the sewered population provide only primary treatment. These include Denver Northside, Denver Eastside, Fruitdale District, Northwest Lakewood District, and Westminster. Eight municipal sewage treatment plants, which have facilities for secondary treatment, are operating at less than 80 percent efficiency for removal of BOD. These include Arvada, Baker District, Clear Creek Valley District, Evergreen, Federal Correctional Institution, North Washington District, Thornton, and Wheatridge. These 8 plants, and the Aurora (Westerly) and South Lakewood District treatment plants, are also removing less than 80 percent of total suspended solids. Plants designed for secondary treatment are considered to be capable of removing at least 80 percent of the BOD and total suspended solids. The treatment efficiency of the municipal sewage treatment plants, including both primary and secondary treatment, is summarized as follows:

Treatment Efficiency	Number of Plants	Percent of Sewered Population
less than 80% BOD removal	13	83
less than 80% TSS removal	15	90

Eight secondary plants are overloaded since average daily flows are in excess of the designed plant capacity. These are Arvada, Aurora (Westerly), Baker District, Clear Creek Valley District, North Washington District, South Lakewood District, Thornton, and Wheatridge. The discharge of raw sewage directly to the stream was particularly evident at the Arvada plant in 1964 when it was estimated that two-thirds of the average daily flow was bypassed. Observations at the Baker District and Thornton plants indicate the bypass of raw sewage primarily during the mid-day period. The large numbers of total and fecal coliform in the streams result from the lack of disinfection facilities or insufficient use of existing facilities. The following plants do not have any disinfection facilities:

- Arvada
- Baker District
- Buckley Air Station
- Federal Correctional Institution
- Fruitdale District
- Littleton
- North Washington District
- Northwest Lakewood District

The following plants have disinfection facilities, but do not provide adequate chlorination:

- Aurora (Westerly)
- Clear Creek Valley District
- Denver (Eastside)
- Englewood
- Evergreen
- Golden (Coors)
- South Lakewood District
- Thornton
- Westminster
- Wheatridge

The daily loading to the Basin streams from municipal sewage treatment plant effluents in the Denver Metropolitan area is estimated at 67 tons of BOD and 43 tons of TSS. The principal source of municipal waste loading is the Denver Northside plant which discharges 53 tons of BOD and 29 tons of TSS to the South Platte River daily. About 10 tons of BOD and 9 tons of TSS are discharged daily into Clear Creek by 9 municipal plants. More detailed information is contained in a Project report entitled "Municipal Waste Treatment, Metropolitan Denver Area."

Industrial Waste Discharges - It is estimated that 75 percent of all industrial waste loading is discharged to municipal sewage treatment plants. The remainder of industrial and/or commercial wastes are discharged to the streams through storm sewers and individual outfalls.

Project studies concerning these discharges included visits to 79 individual industrial operations in the Denver Metropolitan area. Based upon information received from interviews with plant officials, an inspection of the waste disposal facilities and other known data, waste sampling studies were made for 25 separate industrial plants and 44 individual outfalls. The identified sources of industrial waste loading are shown as follows:

Armour and Company
Capitol Rendering Company
Chicago, Burlington and Quincy Railroad
Colorado and Southern Railroad
Colorado School of Mines Research Foundation, Inc.
Continental Oil Company
Adolph Coors Company
Coors Porcelain Company
Denver and Rio Grande Western Railroad
Denver Union Stockyards
E. I. DuPont de Nemours and Company
Empire Petroleum Company - Conoco Asphalt
Gates-Cyclo, Inc.
Gates Rubber Company
General Chemical Division, Allied Chemical Corporation
Kuner-Empson Company, Brighton
Litvak Packing Company
Martin-Denver Division
Packaging Corporation of America
Public Service Company of Colorado
Samsonite Corporation
Stapleton International Airport
Tenneco Oil Company
United Fryer Stillman
Wilson and Company

In addition, Project investigations included foot reconnaissance along the banks of the South Platte River and its tributaries in the

Metropolitan area. A total of 507 outfalls was found in addition to municipal sewage treatment plant discharges. Of this number, 472 outfalls are located within the City and County of Denver. Of the 507 outfalls, 103 were flowing during periods of dry weather and were sampled. Forty-four flowing outfalls are associated with identified industries.

Major storm sewer discharges within the City and County of Denver account for 12 flowing outfalls which include:

Sanderson Gulch
Exposition Avenue
Dry Gulch
Colfax Avenue (2)
12th Avenue (Cherry Creek)
Stout Street (Cherry Creek)
Curtis Street (Cherry Creek)
36th and Arkins
47th Avenue
51st Avenue
Franklin Street near Race Court

These outfalls discharge wastes from a variety of industrial and commercial operations, including filling stations, laundries, warehouses and similar establishments. The 47th Avenue storm sewer discharge, however, is primarily overflow from a sanitary sewage interceptor that is diverted to the storm sewer by means of a weir arrangement.

There are 10 flowing outfalls which are in the vicinity of truck-washing and maintenance operations and carry excessive amounts of oil and ABS. Nine of these outfalls are located in Denver and one in Adams County.

There are 37 additional flowing outfalls, 31 of which are located in Denver, that contribute the remainder of waste loading to the streams.

The origin and loading of waste discharges in the Denver Metropolitan area are summarized as follows:

Number of Outfalls	Origin	BOD Tons/Day	TSS Tons/Day	P.E. BOD
23	Municipal Sewage Treatment Plants	67.0	43.0	804,000
44	Identified Industrial Wastes	6.4	13.8	77,000
12	Major Storm Sewers	6.9	11.2	83,000
10	Truck Washing Operations	1.1	1.3	13,000
37	Other Outfalls	0.9	3.5	11,000
126		82.3	72.8	988,000

The population equivalent for all known waste discharges in the Denver Metropolitan area amounts to 990,000 persons for BOD loading and 730,000 persons for total suspended solids loading. In Figures 2 and 3, the sources and magnitudes of significant waste loading are depicted by means of a bar graph. In Appendix A of this report, the location and a summary of the Project sampling data are given for each of the 126 flowing waste outfalls in the Metropolitan area.

There are 21 separate active gravel processing operations in the Metropolitan area. Eight of these are located along Clear Creek, 6 along the South Platte River, 3 along Bear Creek and 2 in both Cherry Creek and Sand Creek. Some settling is provided for 7 of the gravel-washing activities before returning the waste water to the streams. At 5 installations the waste water is returned to the stream without treatment or the operations are being conducted in the stream bed itself. The remaining firms either utilize a closed circuit where the wash water is reused or conduct a dry operation. The turbidity caused by suspended material from gravel-processing activities will be studied further during the next 12 months.

During the Fall of 1964, a special investigation was conducted in conjunction with the City and County of Denver concerning the disposal of wastes from the meat packing industry in the Denver Metropolitan area. This study covered the collection, handling and disposal of paunch contents, edible and non-edible rendering wastes, and manure from livestock holding pens. Visits were made to 19 meat industry plants, a blood processing plant, and the Denver Union Stockyards. Municipal waste treatment plants, the Omaha, Nebraska plant particularly, have experienced considerable difficulty in handling paunch content wastes. A Project report on packing wastes in the Denver Metropolitan area is given in Appendix B.

It is estimated that 125 tons of paunch contents are handled each operating day at the 13 slaughterhouses in the Denver Metropolitan area. Of the total, it is estimated that 60 tons are discharged to the sanitary sewers. The Denver Northside plant receives about 56 tons and the North Washington District plant 4 tons. Both of these plants are affiliated with the MDSDD#1 which has regulations prohibiting the discharge of paunch contents. The remainder of the paunch contents is removed by in-plant treatment at the slaughterhouses, collected and used by individual farmers and fertilizer operations.

It is estimated that 200 tons of manure are obtained daily from holding pens in the Denver Metropolitan area. This material is collected and transported to fertilizer plants. Estimates indicate that one ton of manure is discharged to the South Platte River daily via surface drains, predominantly from the Denver Union Stockyards.

SIGNIFICANT WASTE LOADS
Denver Metropolitan Area
Population Equivalent For BOD

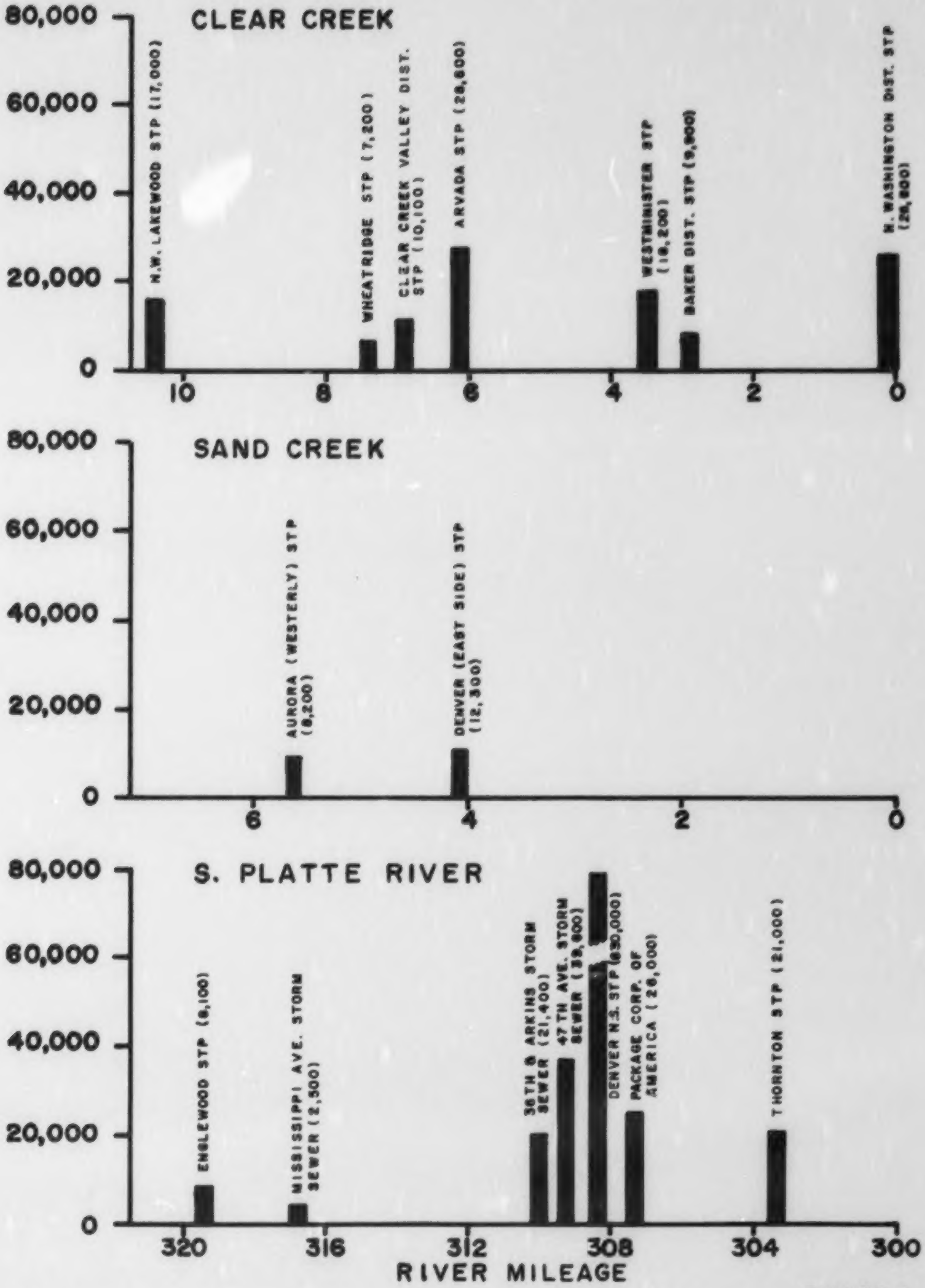


FIGURE 2

SIGNIFICANT WASTE LOADS
Denver Metropolitan Area
Population Equivalent For TSS

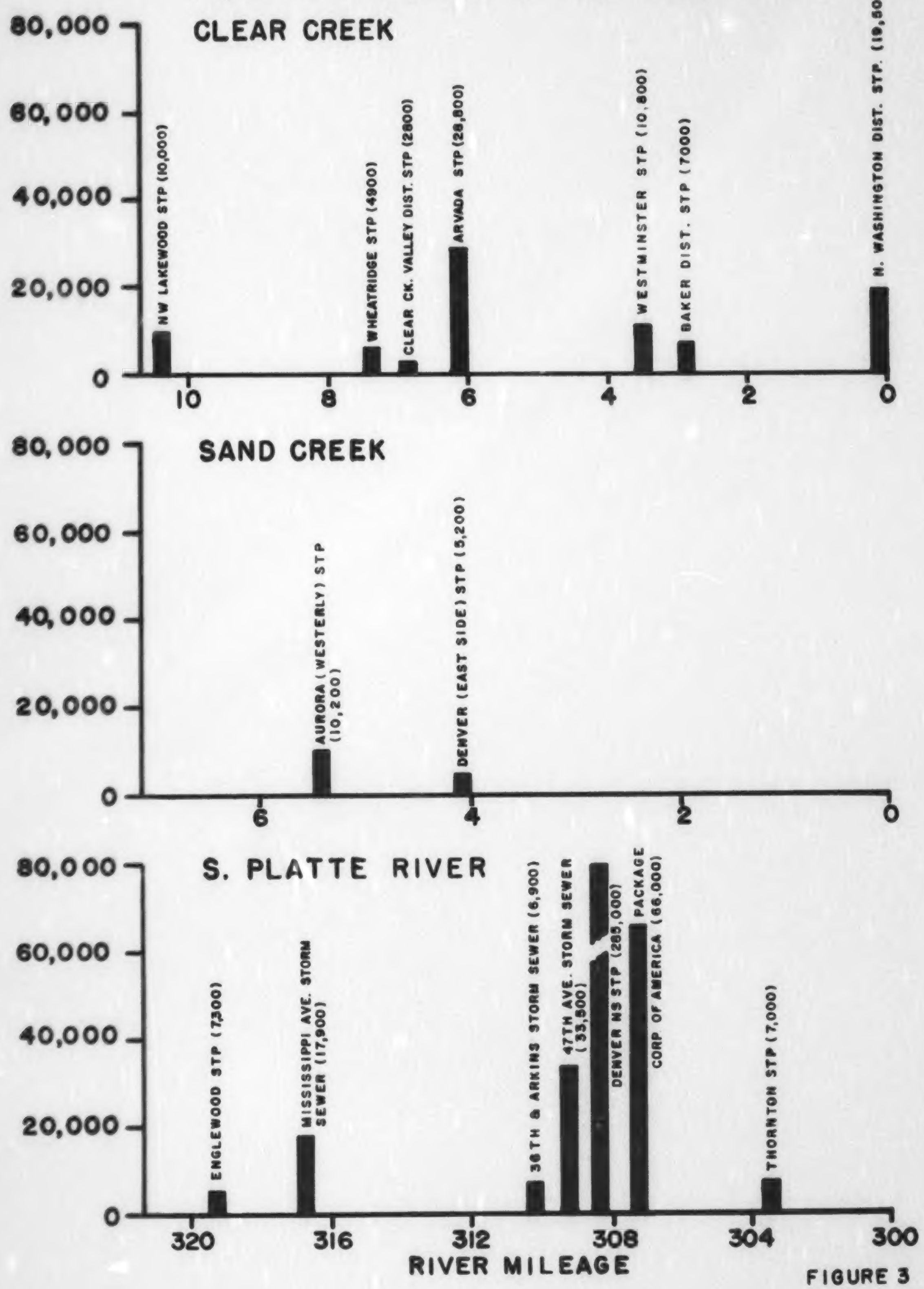


FIGURE 3

All other wastes from the packing industry are placed in the sanitary sewers with the following exceptions, which discharge directly to the South Platte River:

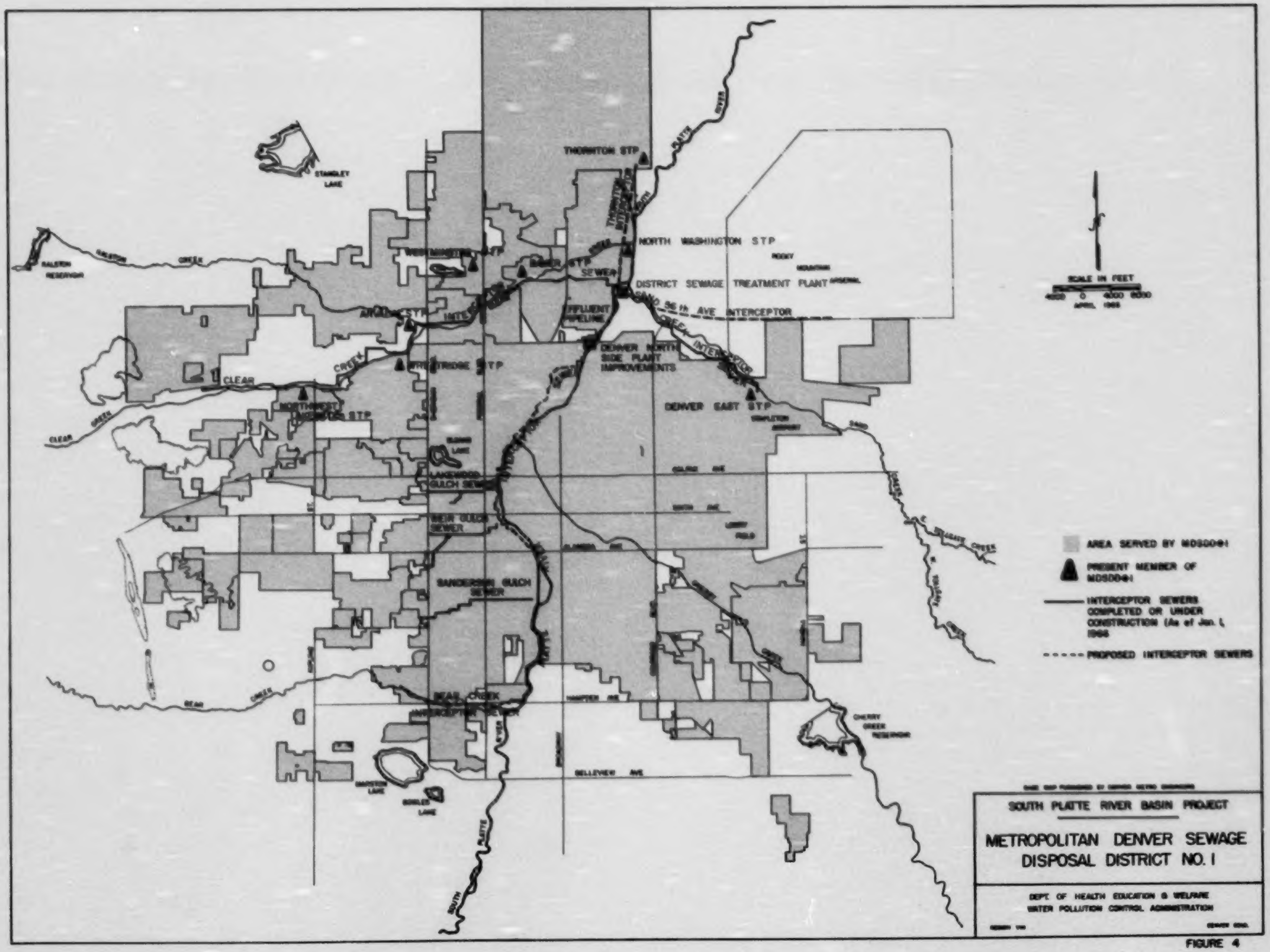
1. Armour and Company, grease and holding pen drainage.
2. Capitol Rendering Co., rendering wastes.
3. Denver Union Stockyards, holding pen drainage.
4. Litvak Packing Co., rendering wastes.
5. United Fryer Stillman Co., miscellaneous packing wastes.

It is understood that municipal authorities will require additional waste removal facilities in certain packing plants prior to discharge into the sanitary sewers.

Metropolitan Denver Sewage Disposal District No. 1 - The Metropolitan Denver Sewage Disposal District No. 1 sewage treatment plant (Metro District plant) is scheduled to commence operation prior to January 1, 1967. This District was formed in 1961 following passage of enabling legislation in the Colorado General Assembly. Shortly thereafter the Denver Metro Engineers were retained by the District, and plans were prepared for the construction of a new metropolitan sewage system, which included a new sewage treatment plant, a series of interceptors, and provided revisions to the existing Denver Northside plant. Essentially the new plant will provide primary treatment and secondary activated sludge treatment with provisions for sludge removal with drying and/or incineration. The Denver Northside facility will be used for primary treatment only, and its entire effluent delivered to the Metro District plant for secondary treatment. All sewage received by the Metro District plant from areas not served by the Denver Northside plant will receive both primary and secondary treatment. The location of the Metropolitan Denver treatment plants affiliated with MDSDD#1, interceptors and area served are shown in Figure 4.

A total of 48 municipalities and sanitary districts, representing about 75 percent of all persons living in the Metropolitan area, will be served by the Metro District facilities. Among these agencies there are presently 9 sewage treatment plants in operation, including 4 plants now providing primary treatment only. The Denver Northside primary plant will operate in conjunction with the Metro District plant facilities. Primary plants operated by Westminster and Northwest Lakewood District may continue to operate, but all effluent will receive primary and secondary treatment at the Metro District plant. The Denver Eastside primary plant will be abandoned and all raw wastes conveyed to the Metro District plant. The remaining 5 plants now designed for secondary treatment will have an option of either discharging all wastes, raw or partially treated, into the Metro District plant; or discharging a portion of effluent to the streams in conformity with State effluent standards and the remainder to the Metro District interceptor. It is likely that these 5 treatment plants will ultimately be abandoned and all raw wastes conveyed to the Metro District plant. Under the agreement between the MDSDD#1 and the member districts and municipalities, no plant can enlarge its present facilities without permission from the Metro District.

The design of the Metro District plant has sufficient flexibility to allow for expansion of both primary and secondary treatment facilities


STANDLEY LAKE
RALSTON RESERVOIR
RALSTON CREEK
CLEAR CREEK
THORNTON STP
NORTH WASHINGTON STP
WESTMINSTER STP
ARVADA STP
WHEATRIDGE STP
NORTHWEST LAKEWOOD STP
DISTRICT SEWAGE TREATMENT PLANT
56th AVE INTERCEPTOR
SAND CREEK INTERCEPTOR
EFFLUENT PIPELINE
DENVER NORTH SIDE PLANT IMPROVEMENTS
DENVER EAST STP
ROCKY MOUNTAIN ARSENAL
LAKEWOOD GULCH SEWER
WEIR GULCH SEWER
SANDERSON GULCH SEWER
BEAR CREEK INTERCEPTOR SEWER
BEAR CREEK
SLOANS LAKE
COLFAX AVE
SIXTH AVE
ALAMEDA AVE
HAMPDEN AVE
BELLEVIEW AVE
LOWRY FIELD
STAPLETON AIRPORT
SAND CREEK
E. TOLLGATE CREEK
W. TOLLGATE CREEK
CHERRY CREEK
CHERRY CREEK RESERVOIR
MARSTON LAKE
BOWLES LAKE
SOUTH PLATTE RIVER
SCALE IN FEET
4000 0 4000 8000
APRIL 1965
AREA SERVED BY MDSDD#1
PRESENT MEMBER OF MDSDD#1
INTERCEPTOR SEWERS COMPLETED OR UNDER CONSTRUCTION (As of Jan. 1, 1966
PROPOSED INTERCEPTOR SEWERS

SOUTH PLATTE RIVER BASIN PROJECT

METROPOLITAN DENVER SEWAGE
DISPOSAL DISTRICT NO. 1

DEPT. OF HEALTH EDUCATION & WELFARE
WATER POLLUTION CONTROL ADMINISTRATION

FIGURE 4

in several stages. Denver Metro Engineers have estimated that expansion of the Metro District plant will be required for primary treatment by 1981 and for secondary treatment by 1982. If the Clear Creek secondary treatment plants are abandoned these expansion dates are estimated, by the Denver Metro Engineers, to be 1979 for primary treatment and 1980 for secondary treatment. According to the design criteria published by MDSDD#1, the Denver Northside plant will be expected to receive a maximum loading of 207,000 pounds of BOD, 259,400 pounds of total suspended solids, and a flow of 97 mgd. This plant is designed to remove 72,500 pounds of BOD or 35 percent of the total loading, and 142,700 pounds of total suspended solids or 55 percent. The remaining 134,500 pounds of BOD and 116,700 pounds of total suspended solids will receive secondary treatment at the Metro District plant.

The Metro District plant's primary treatment facilities are designed to receive 27 mgd and remove 35 percent of 65,000 pounds of BOD and 55 percent of 90,000 pounds of total suspended solids. The discharge from these primary units will be routed to the secondary treatment facilities at the Metro District plant. According to the design criteria mentioned above, the Metro District secondary treatment works are capable of handling 166,350 pounds of BOD, and 147,300 pounds of total suspended solids daily. The following summary is presented to clarify these design data:

Design - Primary Treatment

	Flow mgd	BOD In (lb)	BOD Out (lb)	TSS In (lb)	TSS Out (lb)
Denver Northside Plant	97	207,000	134,500	259,400	116,700
Metro District Plant	27	65,000	42,200	90,000	40,400
Total	124	272,000	176,700	349,400	157,100

Design - Secondary Treatment

	Flow mgd	BOD In (lb)	BOD Out (lb)	TSS In (lb)	TSS Out (lb)
Metro District Plant	117	166,350	22,000*	147,300	28,000*

* Based on 92% overall removal.

Estimates have been developed for flow and BOD and total suspended solids loading to both the Denver Northside and Metro District plants. These estimates are based on the present effluent loading of the treatment plants committed to MDSDD#1, and the additional waste loading to the Denver Northside and Metro District plants as a result of diverting industrial wastes now discharging directly to streams into sanitary sewers. The loading is summarized as follows:

Estimated Loading - Primary Treatment

	Flow mgd	BOD In (lb)	BOD Out (lb)	TSS In (lb)	TSS Out (lb)
Denver Northside Plant	85	203,000	132,000	266,000	120,000
Metro District Plant	16	30,000	19,500	43,000	20,000
Total	101	233,000	151,500	309,000	140,000

Estimated Loading - Secondary Treatment

	Flow mgd	BOD In (lb)	BOD Out (lb)	TSS In (lb)	TSS Out (lb)
Metro District Plant	101	151,500	19,000*	140,000	25,000*

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* Based on 92% overall removal.

A comparison of the design data and the 1967 loading estimated by the Project indicates that the present Metro District primary treatment facilities are adequate with regard to future increased loading. However, an examination of the Denver Northside primary treatment facilities and the Metro District plant secondary treatment facilities shows that the estimated loading will be quite close to design capacity in 1967.

On the basis of these conditions and the probability that the Clear Creek secondary treatment plants will cease to operate within a few years, it is likely that expansion of secondary treatment facilities at the Metro District plant will be necessary much earlier than the anticipated date of 1980.

Effects on Streams - Denver Metropolitan Area

The study of surface streams was started in May 1964 and continued through October 1965. During this period several water quality surveys were made. The study results are grouped as follows:

1. The four main tributary streams entering Denver -- Bear Creek, Cherry Creek, Clear Creek, and Sand Creek.
2. The South Platte River from Littleton to directly below the City and County of Denver.

3. The South Platte River from Denver extending downstream to Greeley.

These investigations covered a total length of 130 miles on the tributary streams and the main-stem South Platte River. Their purpose was to determine the impact of waste discharges from the Denver Metropolitan area to these streams.

Bear Creek - Bear Creek originates on the east slopes of the Continental Divide, flows by the Towns of Evergreen and Morrison, and enters the South Platte River from the west, near the southwest corner of the City and County of Denver. Bear Creek is a typical mountain stream, deriving the majority of flow from melting snowpack. Many irrigation ditches and three municipal water supplies are served by Bear Creek. During the summertime, very low flows are experienced in the stream below Morrison. There is considerable outdoor recreation along the banks of Bear Creek from Evergreen downstream, and large numbers of children participate in water-contact recreation. Water quality studies were conducted on Bear Creek at four stations from Evergreen to the mouth, a total distance of 22 miles.

Chemical results for Bear Creek indicate relatively good water quality existed at all sampling points despite several waste discharges; dissolved oxygen was in excess of 8 mg/l, and 5-day BOD did not exceed 6 mg/l. These values are well within the water quality objectives for Bear Creek. On the other hand, the observed coliform bacteria values in the lower stream approached, and at certain times exceeded the maximum allowable levels of 2400 total coliform per 100 ml, and 500 fecal coliform per 100 ml. In view of existing recreational uses, continuous monitoring of bacteriological quality should be established on Bear Creek.

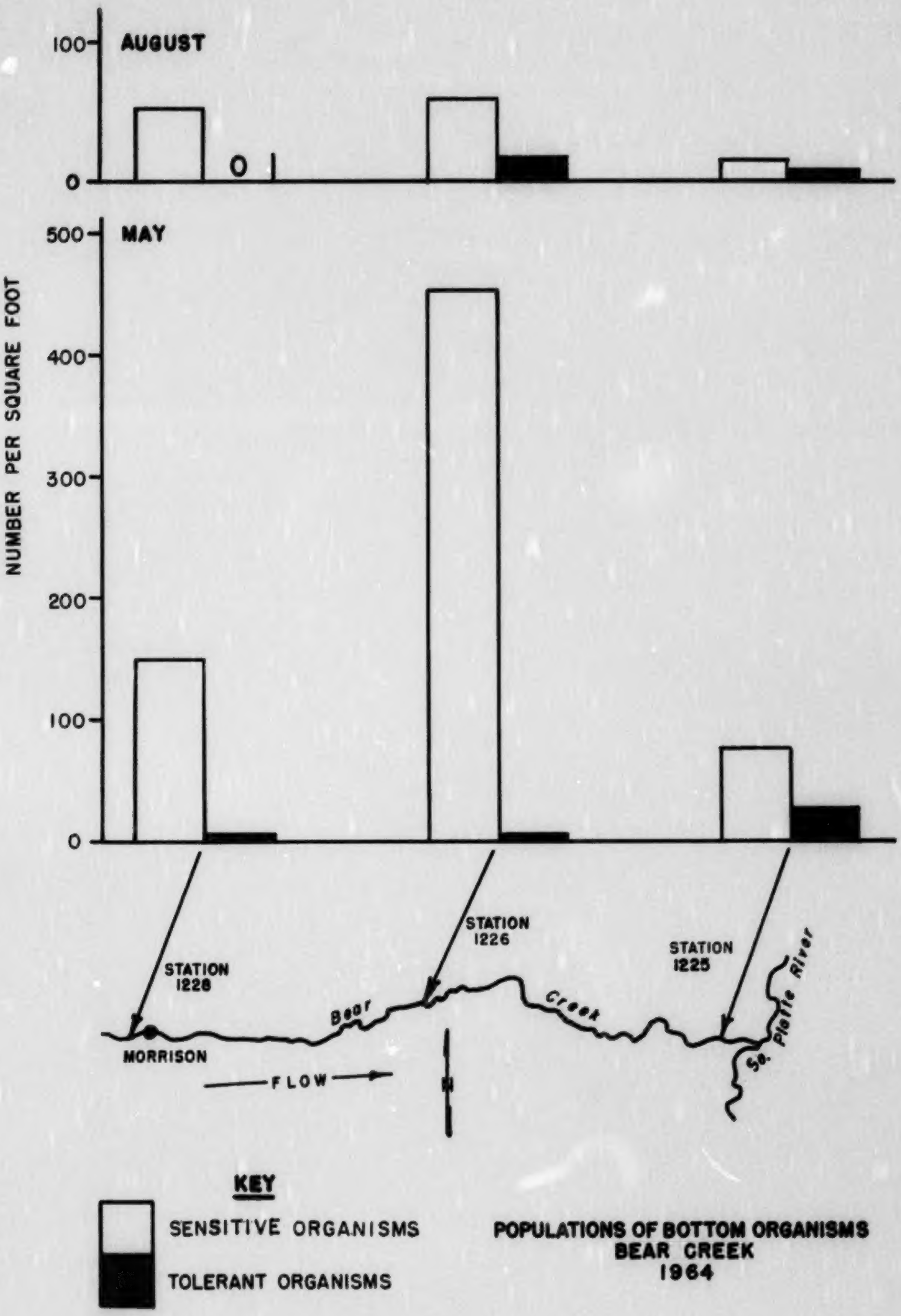
Results of the biological studies on Bear Creek for May and August, 1964, as shown in Figure 5, indicate moderate to heavy numbers of bottom organisms and a fertile stream condition. At the middle station, located at Kipling St., large numbers of nuisance organisms were found in May 1964. These results show the presence of marginal water quality conditions for extended periods of time within the middle portion of the stream and the definite need to eliminate all improperly treated wastes.

Cherry Creek - Cherry Creek starts approximately 15 miles north of Colorado Springs and flows in a northerly direction into Cherry Creek Reservoir near the southeast corner of the City and County of Denver. This Reservoir provides flood control and is used by large numbers of people for fishing, water-skiing, and boating. Directly below the Reservoir, the stream is dry most of the year. After entering the Denver City limits, Cherry Creek once again contains flowing water, due to ground-water inflow and outfall discharges. Project water quality surveys covered this last four miles of flowing stream through the City of Denver to the confluence with the South Platte River in Denver.

Cherry Creek, in August and September 1964, had moderate amounts of mineral salts and significant coliform bacteria. In spite of the many waste discharges, dissolved oxygen was in excess of 8 mg/l and 5-day BOD did not exceed 6 mg/l. From Colorado Boulevard to the stream mouth, total coliform bacteria increased from 7,000 to 23,000 organisms/100 ml, and fecal coliform increased from 790 to 4,500 organisms/100 ml. Between these two points, the BOD increase in the stream was 2200 P.E. This compares favorably with 2300 P.E. of BOD load accounted for by the Project outfall study conducted separately for Cherry Creek.

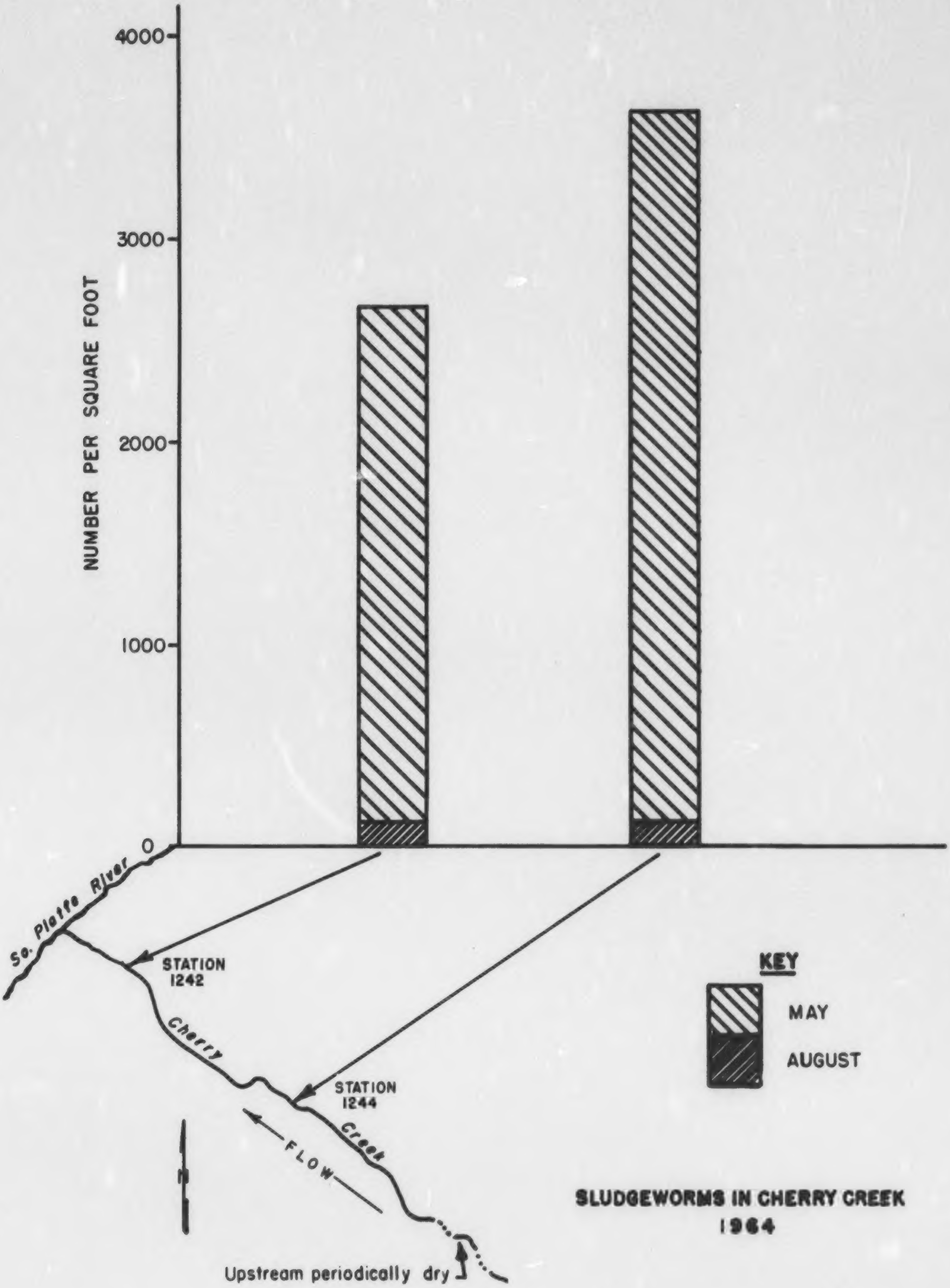
The biological studies undertaken for Cherry Creek in May and August 1964 indicated severe pollution in the lower stream. No pollution-sensitive bottom organisms were present at any time. The entire bottom animal population consisted of pollution-tolerant organisms of which 90 percent or more were sludgeworms. The remaining forms were leeches and snails. The very large sludgeworm populations found in Cherry Creek are shown in Figure 6. In August 1964, an undefined pollutant had killed many pollution-tolerant leeches. These were observed drifting downstream a short distance above the stream mouth. The narrow spectrum and large numbers of tolerant bottom organisms found indicated a high degree of stream pollution. Industrial and commercial waste discharges must be eliminated if good water quality is to be maintained in Cherry Creek throughout Denver.

Clear Creek - Clear Creek is the largest of the four tributary streams in the Denver Metropolitan area. Clear Creek originates on the east slopes of the Continental Divide, about 55 miles west of Denver. It flows eastward through the City of Golden and then through the densely populated suburbs north of the City and County of Denver and joins the South Platte River from the west, downstream of Denver. Clear Creek is a typical mountain stream down to Golden. Clear Creek below Golden is dominated by: 1) extensive diversions of stream water for agricultural irrigation and municipal water; 2) percolation of surface flow into the



POPULATIONS OF BOTTOM ORGANISMS
BEAR CREEK
1964

FIGURE 5



SLUDGEWORMS IN CHERRY CREEK
1964

FIGURE 6

valley-fill aquifer; and 3) large quantities of inadequately-treated sewage discharged into the watercourse. There are approximately 25 agricultural ditches serving 75,000 acres and 9 municipal water supply systems receiving Clear Creek waters from Golden down to the stream mouth. Clear Creek waters are also used for industrial purposes and by many gravel washing operations located along the stream. Recreation is very important in the area above Golden, comprising fishing, wading and picnicking. There are 9 waste discharges entering Clear Creek with a total of 123,000 population equivalents.

Many diversions cause extremely low flow conditions in the lower stream during the summer months. The majority of the streamflow and the accompanying waste load is utilized by the various water users at this time of the year. As a consequence, small amounts of water and wastes enter the South Platte River. In the wintertime, there are minimal diversions and most of the waste load deposited into Clear Creek is discharged to the South Platte River. Project surveys covered 22 miles of Clear Creek from Golden to the stream mouth. Water quality data were collected at four locations in September 1964 to illustrate summertime conditions, and one location near the stream mouth was sampled from January to March 1965 to provide wintertime conditions.

Results of the September 1964 water quality study are shown in Figure 7. Drastic changes occurred from station to station because of large waste load inputs and waste load diversions from the stream. Water quality above Golden was relatively good with a BOD of 2.5 mg/l and dissolved oxygen equal to 9.0 mg/l. Total and fecal coliform values of 12,000 and 600 respectively per 100 ml, were somewhat higher than expected. At Kipling Street, below three sewage treatment plant outfalls, flow in the stream was only 7.5 cfs, compared to 70 cfs at Golden. However, this 7.5 cfs was almost entirely comprised of sewage effluent. Stream values at Kipling Street were 95 mg/l BOD, 1.8 mg/l dissolved oxygen, and 15,000,000 and 4,000,000 total and fecal coliform per 100 ml, respectively. These values show an extremely high degree of pollution in Clear Creek. Further downstream at Sheridan Boulevard, dissolved oxygen increased, and BOD and coliform content decreased in spite of many more waste discharges to the stream. Near the mouth of Clear Creek water quality was not considered important in September 1964, since there was only a bare trickle of water passing this point. The BOD waste load was 23,000 P.E. in the stream at Kipling Street; 43,000 P.E. at Sheridan Boulevard, and only 200 P.E. near the mouth.

The September 1964 study shows large waste loads and very poor water quality in sections of Clear Creek where there are ample amounts of flowing water. The majority of waste load was assumed by the various diversions taking water from the stream, part settled to the stream bottom as sludge banks, and part was removed by stream assimilation.

The wintertime situation in Clear Creek is represented by water quality results collected during January to March 1965 at York Street, one-half mile from the stream mouth. At this time of the year a large portion of the waste load from upstream sources remained in the stream and was carried to the South Platte River. Results at York Street showed

CLEAR CREEK WATER QUALITY
September 21-26, 1964

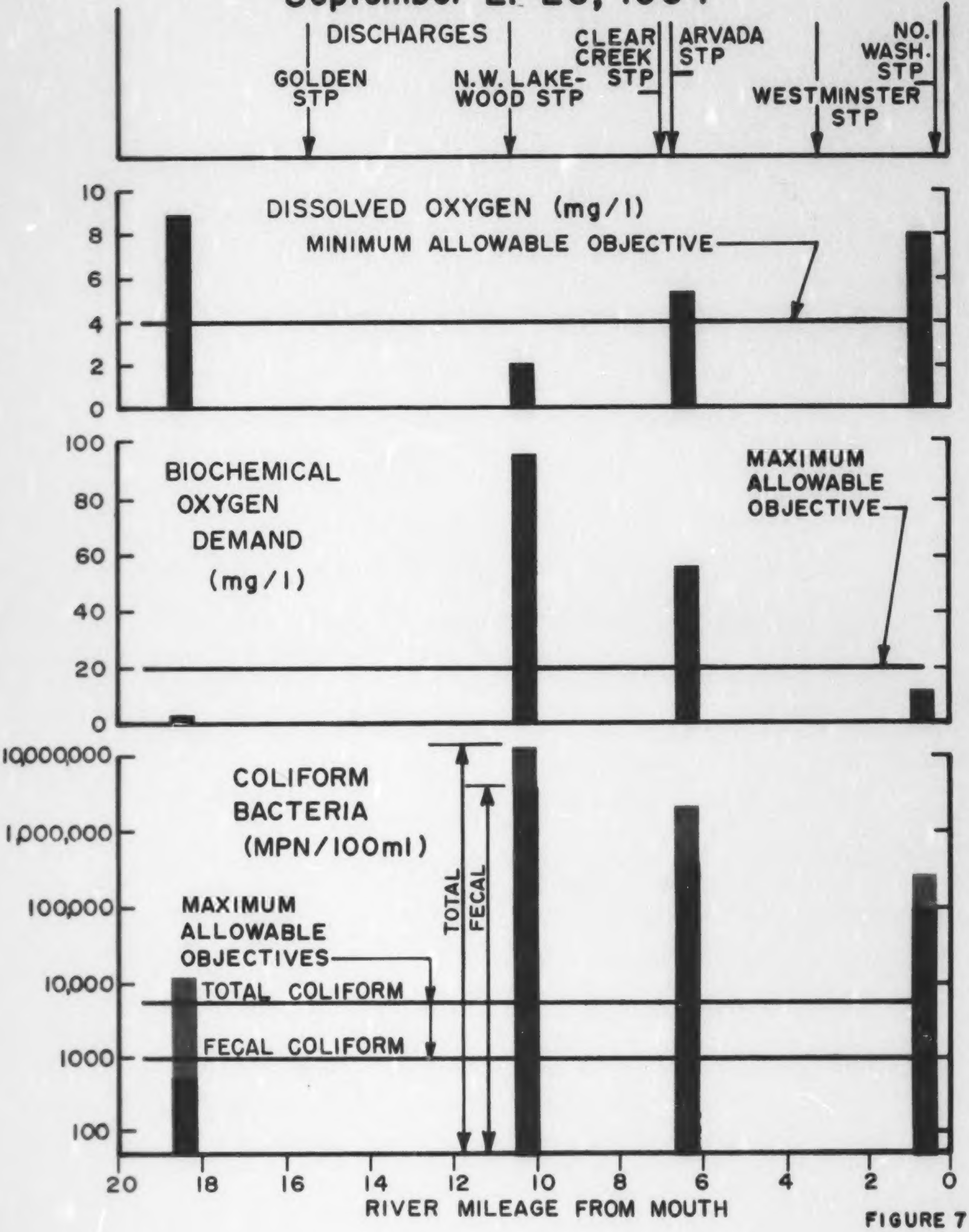


FIGURE 7

a flow of 25 to 30 cfs; BOD from 56 to 82 mg/l; dissolved oxygen between 4.7 and 6.8 mg/l; total coliform from 2.8 to 3.3 million per 100 ml, and fecal coliform from 490,000 to 700,000 per 100 ml. Waste loads found near the mouth varied from 48,000 P.E. in February 1965 to 66,000 P.E. in January and March 1965. To this load must be added another 27,000 P.E. of waste load from the North Washington sewage treatment plant located directly at the stream mouth. The wintertime conditions in Clear Creek, in many respects, are far worse than the summertime.

Water quality studies on Clear Creek show gross pollution at all points downstream of Kipling Street, a distance of 10.2 miles to the stream mouth. Observed BOD values from Kipling Street downstream were up to five times the maximum allowable objectives and coliform bacteria values were up to 4,000 times the maximum allowable levels. During the wintertime, Clear Creek is a large contributor of waste load to the South Platte River, discharging approximately 87,000 P.E. of waste to the main River. The use of these polluted waters for municipal water supply, crop irrigation and recreational purposes, is considered hazardous.

Sand Creek - Sand Creek originates southeast of the City of Aurora, encircles north of the City and County of Denver, through the Commerce City area, and joins the South Platte River from the east side. Sand Creek generally has little or no flow above Aurora. Below this point, the stream is largely comprised of municipal and industrial waste effluents, most of which are inadequately-treated. Project study of individual waste outfalls and sewage treatment plant effluents conducted throughout 1964-1965 showed a total waste flow of 10.5 cfs, containing 25,000 P.E.

of BOD, are discharged into Sand Creek. Sand Creek carries large waste loads into the South Platte River.

Project water quality surveys were carried out on Sand Creek in September 1964, and again in September-October 1965. The stream was sampled below the Denver Eastside and Aurora Westerly sewage treatment plant at mile 3.6, and also at the mouth. The two treatment plants above represent the largest waste loads to the stream.

The September 1964 results are illustrated in Figure 8. The stream at this time was found to be comprised almost entirely of waste effluent. The upstream sampling location below the Denver Eastside sewage treatment plant showed 93 mg/1, 5-day BOD; an average dissolved oxygen of only 1.0 mg/1 with many individual values between 0.0 and 0.5 mg/1; total coliform bacteria of 23 million per 100 ml, and fecal coliform of 5.4 million per 100 ml. These values are indicative of primary-treated sewage rather than stream waters, and furthermore, near septic or anaerobic conditions were present in the stream. This location was found to contain 35,000 P.E., based on BOD load and 150,000 P.E., based on suspended solids load.

Sand Creek, at its mouth in September 1964, as illustrated in Figure 8, showed only small reduction in waste concentrations compared to the upstream location. However, because of increased flow, the total BOD waste load was 50 percent greater and the suspended solids load was twice the upstream amount.

Survey results from September-October 1965 showed worse conditions than in 1964. Coliform bacteria and dissolved oxygen levels were near

SAND CREEK WATER QUALITY
September 21-26, 1964

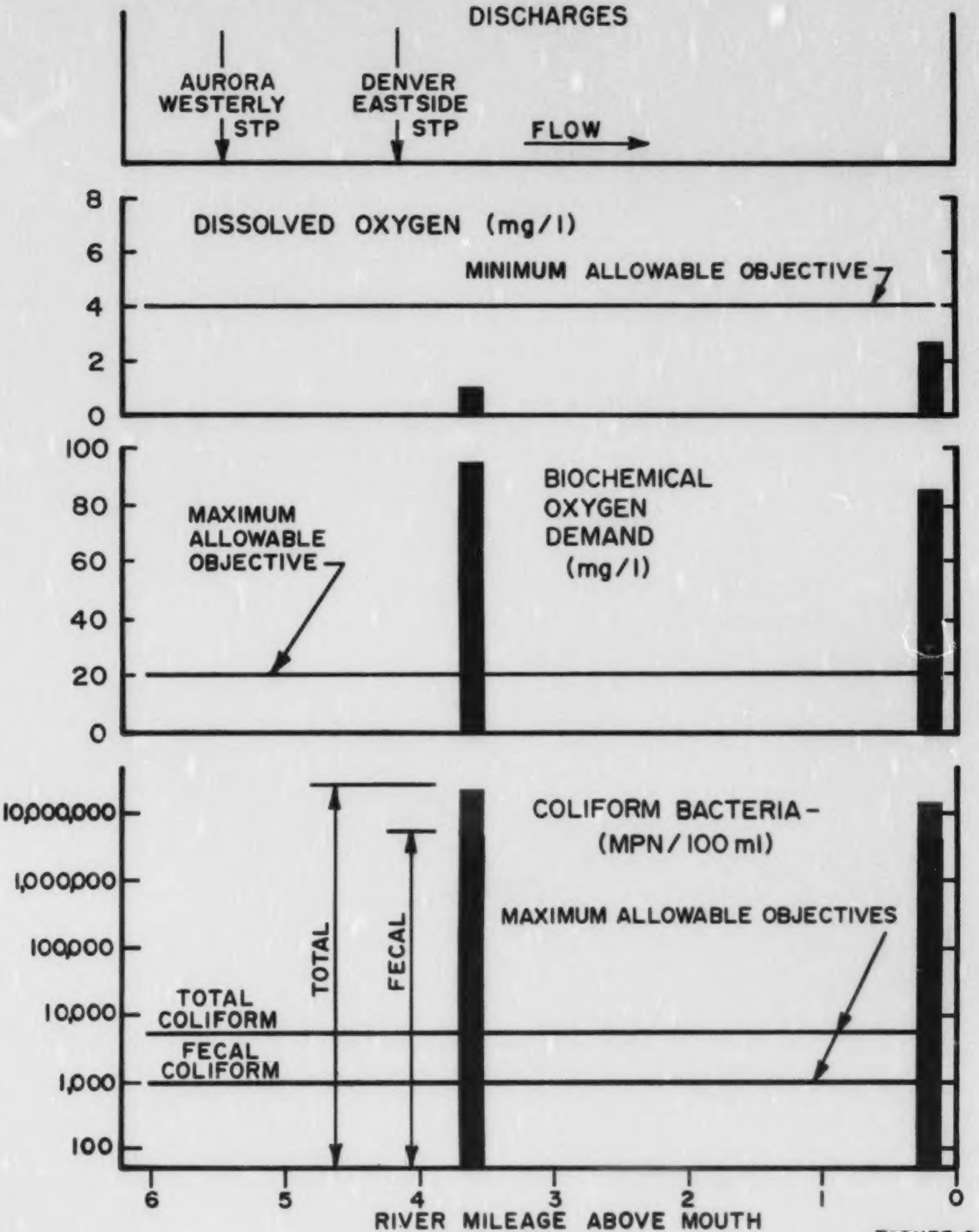


FIGURE 8

the same, but BOD concentrations as measured at the mouth of the stream increased to between 135 and 168 mg/l. Excessively high waste concentrations in Sand Creek characterize this stream as being an open sewer. Coliform bacteria and ABS levels found in the stream are equivalent to those expected in raw municipal sewage. Observed BOD values were up to eight times the maximum allowable objectives and coliform bacteria were up to 4,500 times the maximum allowable levels.

The 1964-1965 stream survey results consistently showed around 70,000 P.E. of BOD load and 300,000 P.E. of suspended solids load discharged to the South Platte River. Waste loads from Sand Creek are equal to, or greater than, those imposed on the main-River by Clear Creek. The stream data also show that the estimate of waste load from individual outfalls and waste treatment plants on Sand Creek is on the conservative, or low side.

South Platte River from Littleton through Denver - An intensive water quality survey of the main-River from above Littleton downstream to one mile below the Denver Northside sewage treatment plant was conducted in August 1964. Direct uses of water in this stretch of stream include municipal water supply above the Littleton sewage treatment plant, water-contact recreation in the Littleton-Englewood area, withdrawals for industrial cooling purposes, 2 to 3 small agricultural ditches, and the Burlington-O'Brian Canal receiving River water a short distance below the waste discharge of the Denver Northside treatment plant. Over this 17 miles of stream there are three municipal sewage treatment plants and more than 75 outfalls discharging waste material directly to the

River. Total waste load entering this section of the South Platte River approximated 780,000 P.E. from the Project study of separate municipal, industrial, and storm sewers in 1964-1965. The Denver Northside sewage plant was found, in 1964, to contribute 630,000 P.E., or 80 percent of this total waste load. Results of the August 1964 water quality survey are illustrated in Figure 9.

The August 1964 study shows satisfactory dissolved oxygen at all points above the Denver Northside sewage plant, but shows a decrease from 11 mg/l directly above, to 2.5 mg/l dissolved oxygen one mile below this plant. Five-day BOD in the flowing waters was 2 mg/l above Littleton, increasing to around 5 mg/l in the center of Denver, and then to 10 mg/l in the heavy commercial area of North Denver. The impact of the Denver Northside treatment plant is striking, as shown by the furthest downstream sampling point with 85 mg/l BOD in the River directly below this very large waste load. Total coliform bacteria levels were low above Littleton, increased sharply below the Littleton and Englewood sewage treatment plants to around 300,000 per 100 ml, and then showed a gradual decline to about 75,000 per 100 ml above Cherry Creek. Total coliform levels were maintained between 49,000 and 105,000 per 100 ml until the Denver Northside treatment plant was reached, at which point the total coliform content in the River increased 100 times to the level of 8 million organisms per 100 ml. The fecal coliform pattern was the same as total coliform, but values were lower, as expected. Coliform levels below the Northside treatment plant were 10,000 to 20,000 times greater than the densities found at the location above Littleton. Through the study area, observed

QUALITY OF SOUTH PLATTE RIVER WATER
Denver Metropolitan Area
August 1964

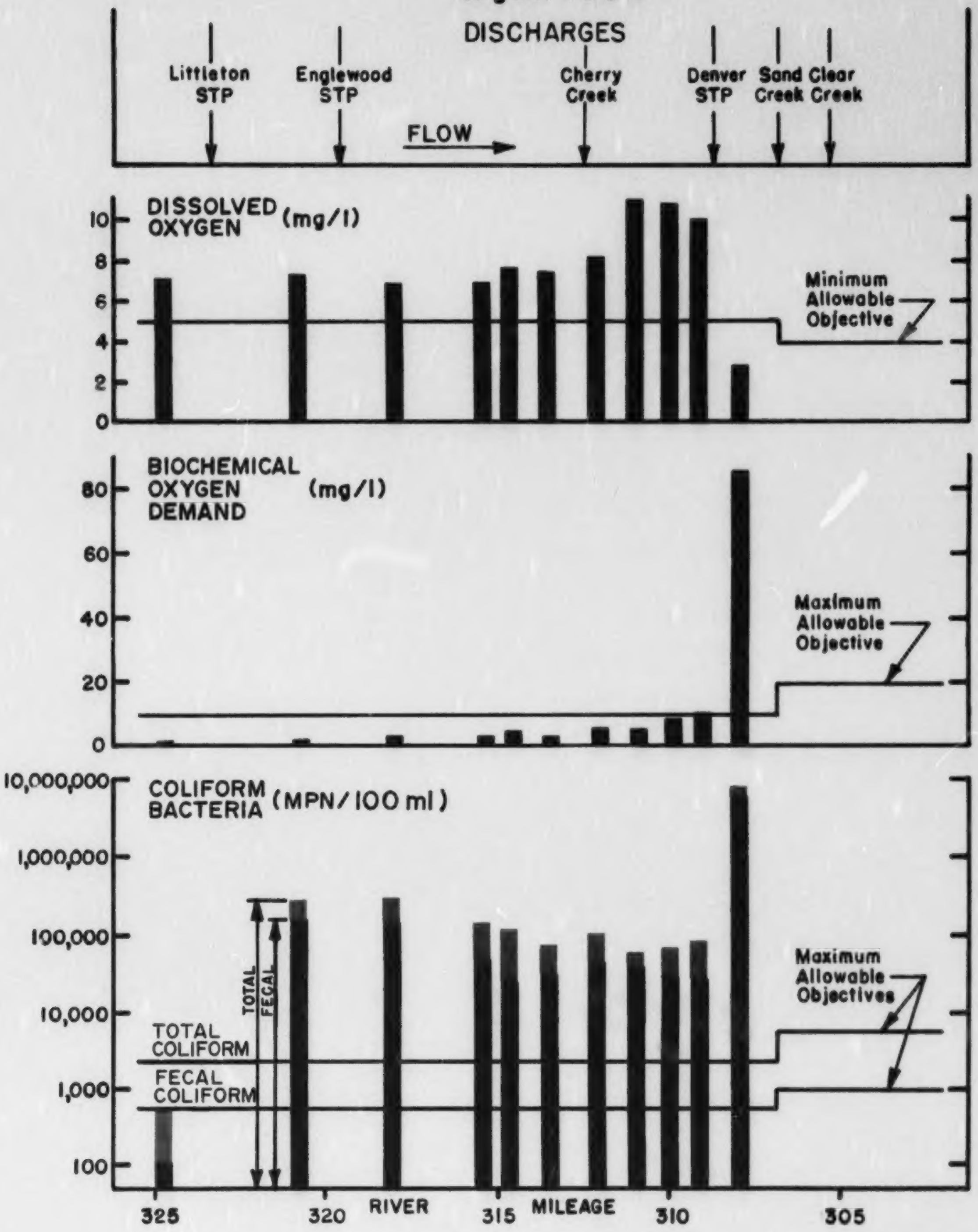


FIGURE 9

coliform values were tremendously higher than the maximum allowable stream objectives and the same was true for BOD below the Denver Northside treatment plant.

The quality of flowing waters in the South Platte River is affected by waste material settling to the stream bottom. Numerous observations have been made on sludge deposits in many areas of the River downstream of Littleton through the City of Denver, and particularly below the Denver Northside treatment plant. Settling reduces the waste load carried in the flowing waters and gives the impression the stream is in better condition than is actually the case. Sludge deposits represent a definite liability which must be accounted for in determining the true condition of a stream. A significant portion of the load discharged in Denver settles on the River bottom and the water quality results given above and below must be viewed critically with this principle in mind. Streamflows in the summertime through Denver are relatively high and during the August 1964 survey these flows approximated 140 cfs at the Denver 19th Street gage.

Wintertime and low flow conditions in the South Platte River through Denver are represented by a water quality survey conducted from December 1964 through March 1965. The flow at the Denver gage averaged about 50 cfs for the particular days of sampling. This study covered the River from Florida Avenue on the south side to 4 miles below the Denver Northside treatment plant on the north side. Results of this study are illustrated in Figure 10.

The wintertime study shows essentially the same dissolved oxygen picture as August 1964. The BOD concentrations on the other hand were two or three times higher than corresponding values obtained during the summer study. Above the Denver Northside treatment plant, BOD content exceeded, at certain locations, the maximum allowable objective even though the majority of upstream waste load was settling to the River bottom. Directly below the Denver treatment plant, the average BOD concentration in the River was 170 mg/1, twice the summertime 1964 value noted for this same location. This was 17 times the maximum allowable BOD level. Coliform bacteria concentrations over the stream stretch were, in all cases, many times greater than the maximum allowable bacteria levels. The above results show that quality of South Platte River waters in the wintertime is, in many respects, worse than summertime.

South Platte River below Denver - Direct uses of South Platte River waters from Denver to Greeley consist almost entirely of agricultural withdrawals received by some 25 canals serving 200,000 acres of irrigated land. In June 1965 a serious flood on the South Platte River caused widespread damage. The Denver Northside plant was also affected and there was essentially no waste treatment at this installation until the end of September. From primary treatment before, to no treatment during the damage period, the discharged wastes increased from 630,000 P.E. to 1,080,000 P.E. Principal waste loads below the City of Denver include Sand Creek and Clear Creek, previously described, and an additional 70,000 P.E. from various outfalls, most of which reach the River in the few miles directly below Denver.

For the purpose of defining conditions in the South Platte River downstream of Denver, two intensive water quality surveys were undertaken

QUALITY OF SOUTH PLATTE RIVER WATER
Denver Metropolitan Area
December 1964 - March 1965

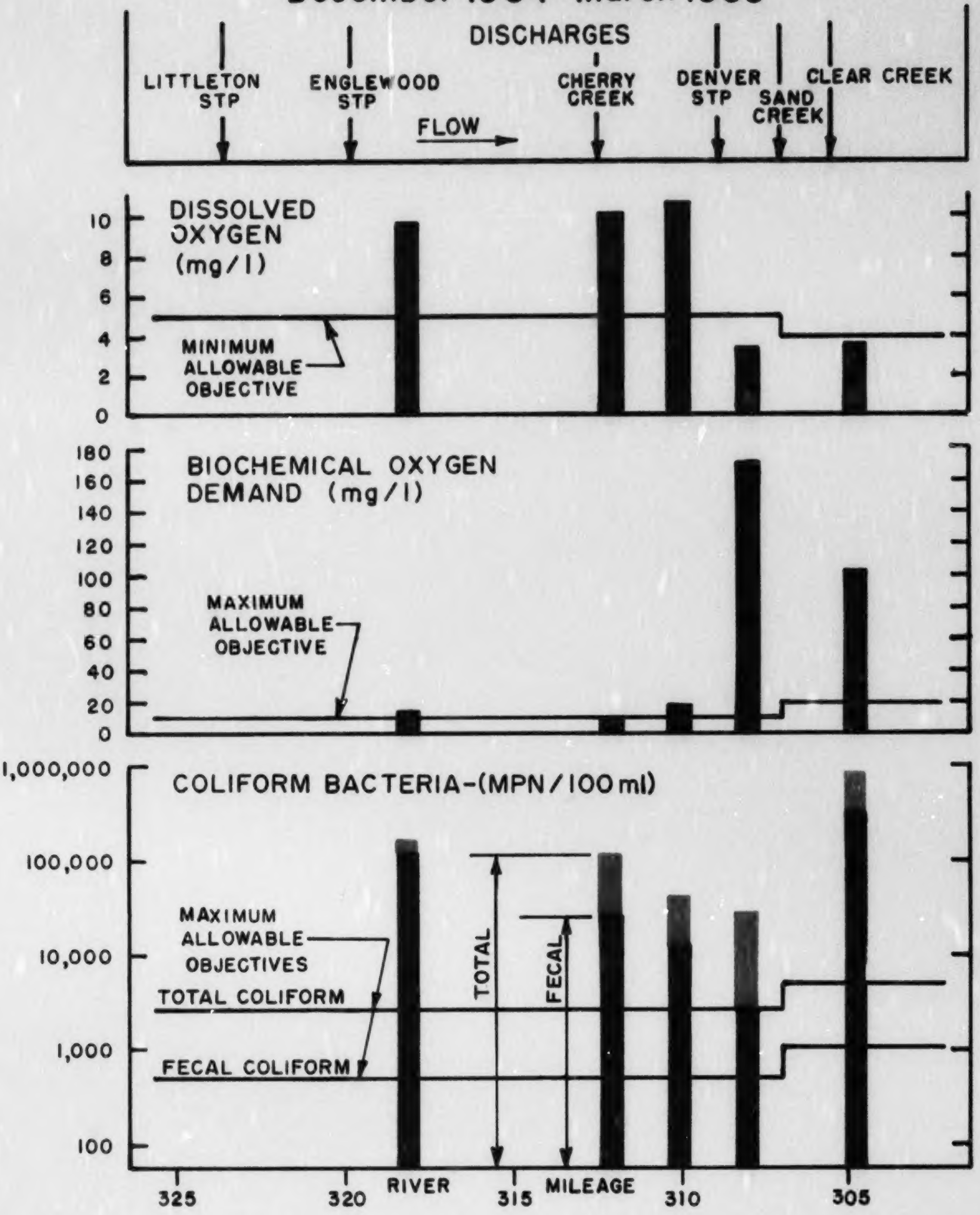


FIGURE 10

in 1965. One survey was conducted in mid-September 1965 at a time when irrigation canals were withdrawing large amounts of water, together with large waste loads from the River. The second survey was carried out in early October 1965 during a period when there were minimum irrigation withdrawals below Denver. Neither of these studies were conducted during the period of sugar beet processing.

The water quality study of September 15-16, 1965 included 16 sampling stations and covered the South Platte River from the 19th Street Denver gage down to the Big Thompson River, a total distance of 54 miles. Streamflow was 380 cfs at the Denver gage. However, 43 miles downstream and immediately above St. Vrain Creek, this flow was reduced to only 30 cfs because of many intervening diversions. The Burlington-O'Brian Canal, directly below the Denver Northside treatment plant, was diverting 223 cfs, or 45 percent of the flow present in the River during this period. The flows and waste loads contributed to the South Platte River by Sand Creek, Clear Creek and other tributary streams were completely overshadowed by South Platte River flows and waste loads directly below the Northside treatment plant. Results of the September 1965 study are illustrated in Figure 11.

The dissolved oxygen picture in September 1965 showed a very drastic change and almost complete loss of oxygen resources below the City of Denver. At a point four miles below the Denver Northside plant, the average dissolved oxygen content was only 0.2 mg/l and 86 percent of the samples collected at this location were completely devoid of oxygen. It is interesting to note that this condition of absolute degradation was caused by only 55 percent of the upstream waste load reaching this point since 45 percent of the load was previously removed from the stream by diversions to the Burlington-O'Brian Canal. Other agricultural diversions downstream removed another 19 percent of the original waste load from Denver, but still there was a pronounced oxygen sag for a long distance downstream. Intense stream pollution caused dissolved oxygen levels to be less than 4 mg/l in the 33 miles of River below Denver.

The 5-day BOD in the River increased from 14 mg/l above the Northside treatment plant to 65 mg/l one mile below this waste source. A total waste load of 1,050,000 P.E. was present in the River waters one mile below the plant. However, calculations show than an additional 170,000 P.E. of waste load was settling to the stream bottom between 19th Street and the station located one mile below the plant. Of the 1,050,000 P.E. total load in the River waters, the Burlington-O'Brian Canal received 480,000 P.E. by diversion, and 570,000 P.E. remained in the River below the Canal. Appreciable settling of wastes also occurs in the River downstream of the Burlington-O'Brian Canal past Brighton. There are extensive sludge banks throughout Denver, and for at least 20 miles below Denver. Even though large amounts of BOD were removed from the flowing River waters by waste settling, canal diversions, and stream assimilation, the BOD concentrations in the River water exceeded the maximum allowable objective of 15 mg/l all the way downstream to Platteville. This accounted for 30 miles of stream below Denver.

The coliform picture in the South Platte River downstream of Denver showed close agreement with the other findings in September 1965, all of

QUALITY of SOUTH PLATTE RIVER WATER

Denver to Big Thompson River
September 1965

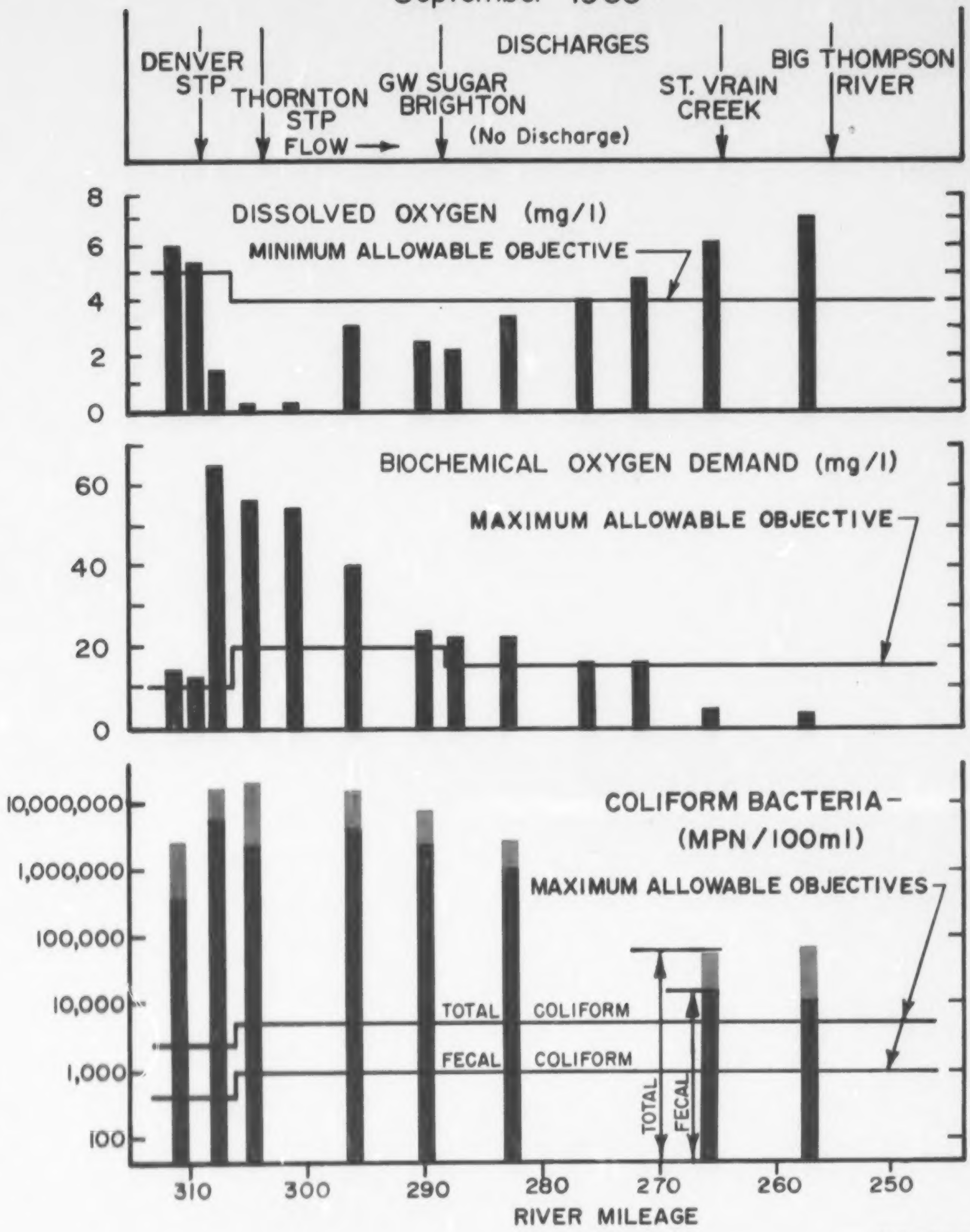


FIGURE II

which show severe degradation over the study area. Total and fecal coliform bacteria reached peak levels of 18 million and 5.1 million per 100 ml respectively, within one to five miles below the Denver Northside treatment plant. These coliform values are extremely high for any class of stream. Both total and fecal coliform were in excess of one million per 100 ml downstream past Brighton, and at the last sampling point 50 miles below Denver. The River contained 75,000 and 11,000 total and fecal coliform per 100 ml, respectively. Coliform densities over the entire stretch of River tremendously exceeded the maximum allowable stream objectives.

The water quality study of October 7-10, 1965 included 18 sampling stations and covered the South Platte River from the 19th Street Denver gage to one mile upstream of the Cache la Poudre River near Greeley. Total stream distance was 66 miles. Streamflow was 305 cfs at the Denver gage and 1185 cfs above the Cache la Poudre River. Irrigation canals were withdrawing relatively small amounts of water during this period and the majority of Denver Metropolitan waste load was carried a long distance downstream. Conditions in early October 1965 were considerably different than mid-September 1965. The results of this study are illustrated in Figure 12.

Dissolved oxygen in October 1965 was reduced from 7.0 mg/l at 19th Street in Denver, to an average value of only 1.0 mg/l eight miles below the City of Denver. The dissolved oxygen did not recover to the allowable stream objective of 4.0 mg/l until 39 miles below Denver.

The 5-day BOD in the River in October increased from 14 mg/l above the Northside treatment plant to 51 mg/l one mile below the plant. This treatment installation was again back in operation. A total waste load of 800,000 P.E. was present in the River waters directly below the plant and calculations based on the survey data show that an additional 95,000 P.E. of waste load was settling to the stream bottom between 19th Street and the station located one mile below the plant. Because of minimum diversions, the South Platte River above the Cache la Poudre still carried a waste load of 560,000 P.E., the large majority of which originated from the Metropolitan Denver area. Greater streamflows in the downstream sections diluted the BOD concentrations in the River water. Nevertheless, BOD values over the entire stretch of River from Denver to Greeley were in excess of the desired allowable objectives. The stream distance so affected was 54 miles.

Total and fecal coliform bacteria reached maximum values of 8.6 and 3.2 million, respectively per 100 ml in the area of Brighton. Very high coliform densities were found in the River waters at all locations. The bacteriological levels were still high at the last station above the Cache la Poudre and South Platte River waters at this location contained 940,000 total coliform and 56,000 fecal coliform organisms per 100 ml. The bacteriological quality of South Platte River waters running the entire distance from Denver to Greeley was extremely poor.

Biological studies conducted in May 1964 covered the South Platte River from above Littleton to Platteville, about 30 miles below Denver. Stream bottom animal populations were studied and Figure 13 shows the numbers of pollution-sensitive and pollution-tolerant forms that were found at each sampling location. The response of the biological

QUALITY of SOUTH PLATTE RIVER WATER
Denver to Greeley
October 1965

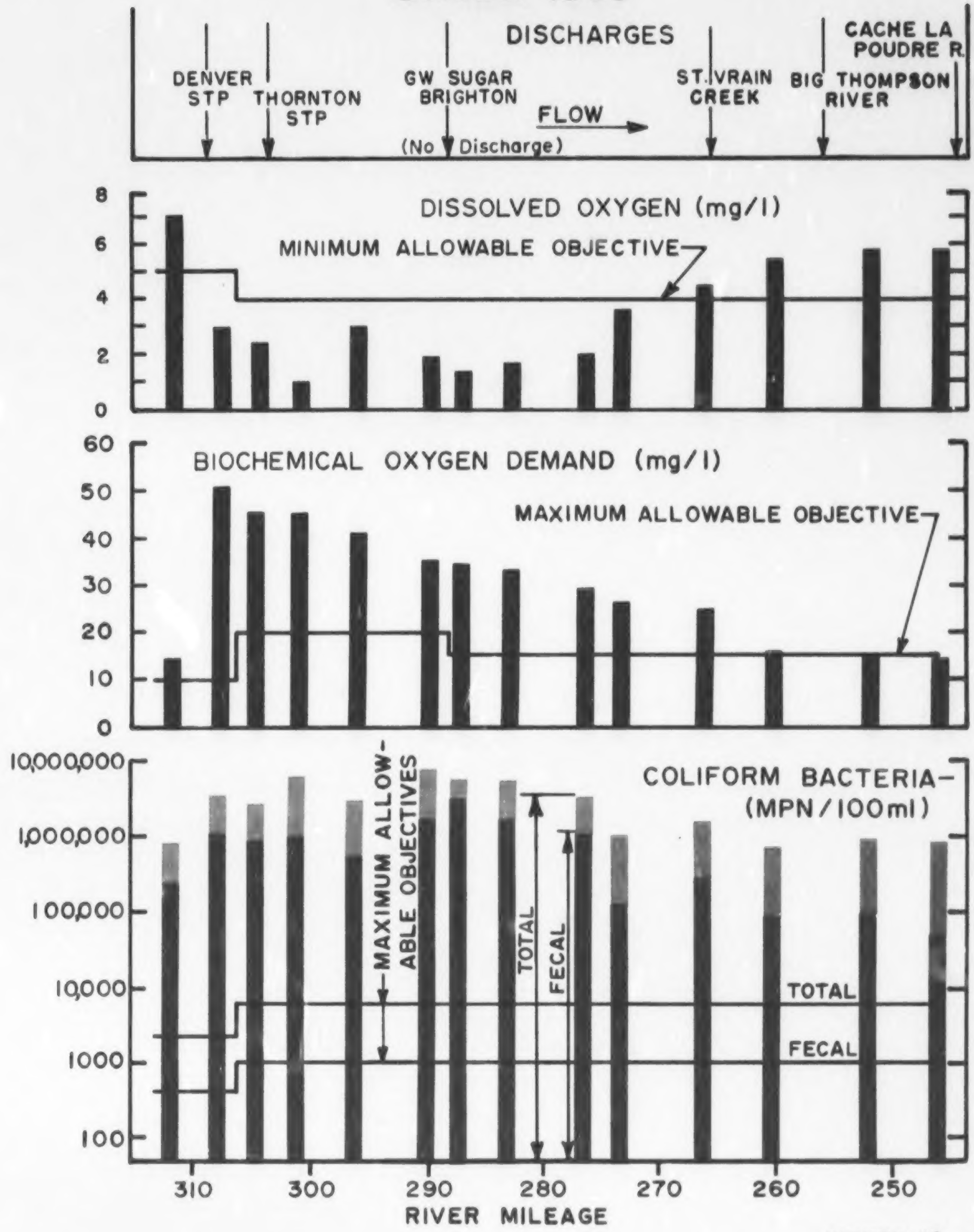
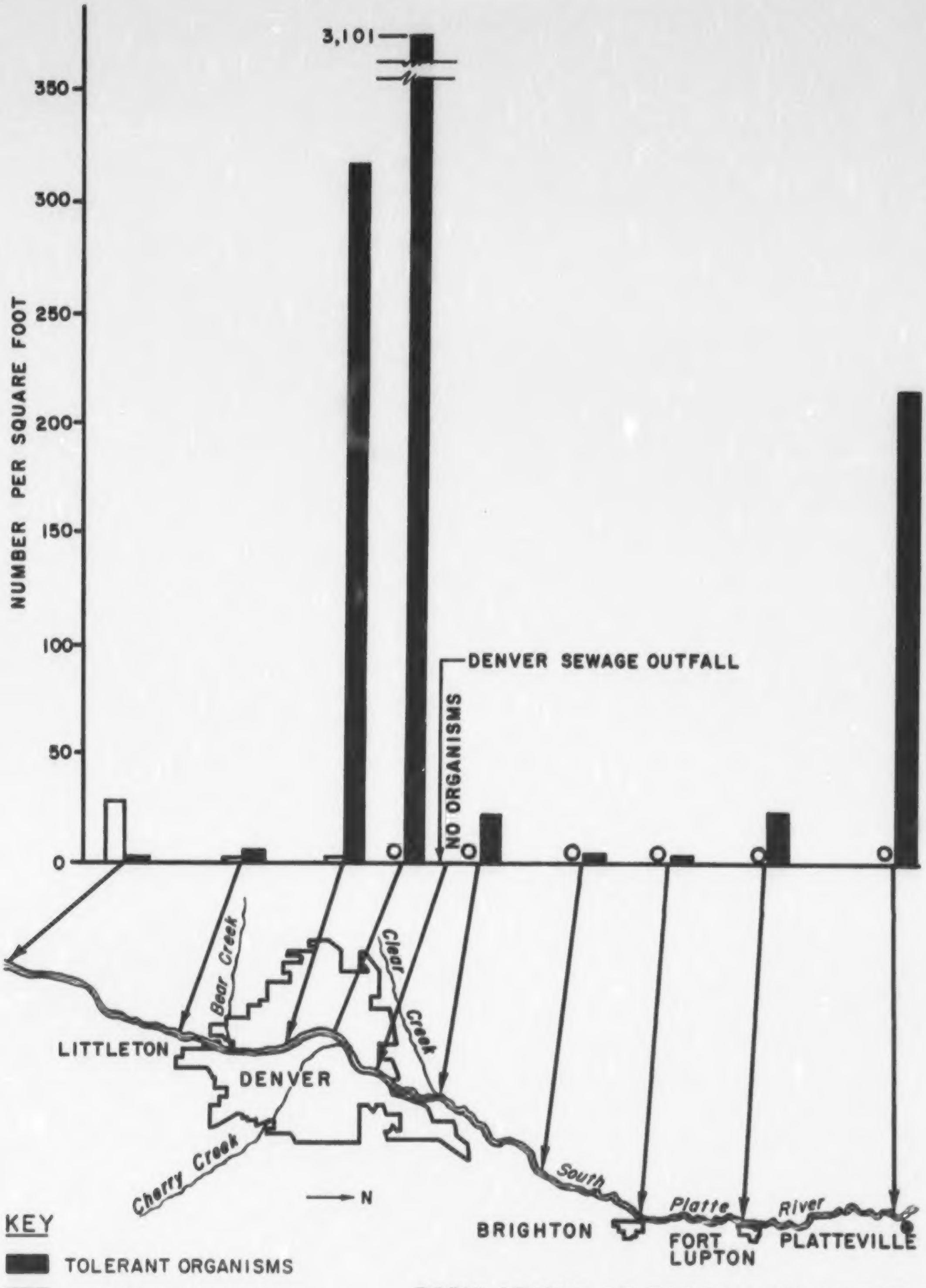


FIGURE 12



POPULATIONS OF BOTTOM ORGANISMS
LITTLETON TO PLATTEVILLE, COLORADO
MAY, 1964

FIGURE 13

community to progressively severe pollution is briefly described in stages as follows: 1) clean streams produce a balanced biota including a broad spectrum of all organisms; 2) moderate pollution produces increasing numbers of tolerant species at the expense of the sensitive forms; 3) severe pollution creates large numbers of only one or two tolerant species and complete elimination of sensitive forms; and, finally 4) gross degradation eliminates all forms of biological life on the stream bottom.

As shown by Figure 13, all four conditions just defined are much in evidence. The biological community above Littleton has a predominance of sensitive organisms over tolerant organisms. Upon entering Littleton and Denver, the sensitive types diminish and the tolerant forms greatly increase until the situation exists immediately above Cherry Creek where no sensitive forms were present, and there were 3,100 tolerant organisms per square foot of River bottom. At Franklin Street, immediately below the Denver Northside plant, all forms of bottom life were completely eliminated. Tolerant organisms, particularly sludgeworms, did not really become established until Platteville, and throughout this entire 30 miles of stream below Denver, no sensitive organisms were found. Biological recovery only started around Platteville. One of the major deterrents to biological life is the abnormally large amounts of sludge deposits found on the bottom of the River, particularly below the Denver Northside treatment plant. During the September 15-16, 1965 survey, it was calculated that 33 tons per day of solids, expressed as 5-day BOD, were being deposited along the bottom of the stream. Essentially, all settleable solids must be removed from waste discharged for elimination of this most undesirable problem.

Ground Water Studies

In addition to the surface water investigations, the Project undertook a program to determine sources and the extent of pollution in the water-bearing formations of the Denver Metropolitan area. This study was conducted during the period from May 1964 to March 1965 and further sought to determine what measures might be taken to minimize or eliminate deterioration of the chemical quality of ground water. More detailed information is contained in the Project report entitled, "Ground-Water Pollution in the South Platte River Valley Between Denver and Brighton, Colorado."

The fresh water-bearing formations in the Denver Metropolitan area consist principally of the bedrock zones and the overlying valley-fill deposits. Water wells located in the bedrock aquifers range from depths of between 100 and 2000 feet below the land surface; large capacity wells yield an average of 50 gpm. Although water from these formations is usually considered to be of good quality, the low transmissivity of the water-bearing materials in the bedrock precludes any wide-scale use from these sources. Since the use of water from bedrock formations is quite limited and there is a general absence of contamination, the investigation was essentially directed to the shallow valley-fill aquifer.

The valley-fill deposits consist chiefly of unconsolidated sands and gravels that occupy the principal stream valleys. Over 3800 shallow wells currently withdraw water from these formations in the Denver

Metropolitan area. Most of the large capacity wells are concentrated in the valleys of the South Platte River, Cherry Creek, Sand Creek, and Clear Creek, where maximum thickness of water-bearing materials occur. Yields of large capacity wells are reported to commonly yield 500 gpm and range to 2000 gpm. Approximately 850 wells supply water for irrigation; over 2,000 wells supply individual residences, 96 wells furnish part, or all, of the water delivered by 18 public water systems in the area, and the remaining wells are utilized for industrial and commercial purposes.

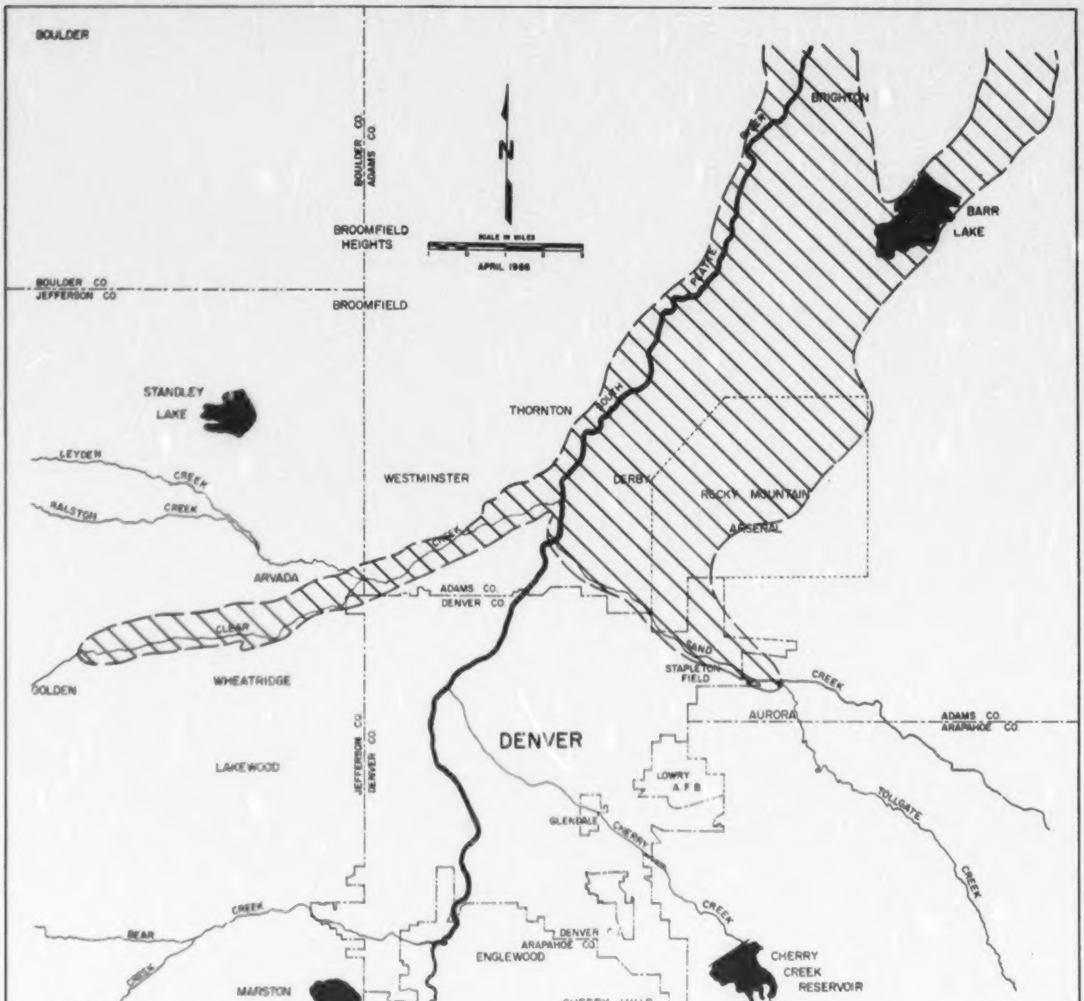
The valley-fill aquifers are very susceptible to pollution. The permeable valley-fill deposits are exposed at the land surface and generally extend to depths of less than 100 feet. Polluted water or other liquids discharged on much of the land surface in the area readily enter the shallow unconfined aquifers. Widespread pollution of the shallow aquifers has occurred in the valleys north of Denver; whereas localized instances of pollution have occurred in other parts of the Denver Metropolitan area.

Contaminants found in the shallow aquifer during Project studies include alkyl benzene sulfonate (ABS), nitrates, oils, pesticides, herbicides, arsenic, and salts. As shown in Figure 14, widespread ABS pollution occurs north of Denver in the valleys of the South Platte River, Sand Creek, and Clear Creek. Concentrations of ABS within the shaded areas of this figure range from 0.1 to 1.0 mg/l. Much of the flow in the above streams consists of municipal and industrial waste discharges. A large portion of the sewage-laden waters of Clear Creek and the

South Platte River are diverted to irrigation ditches, and, in turn, enter the shallow aquifer from seepage in unlined canals and reservoirs and from percolation of water applied on irrigated farms. A substantial part of the waste discharged into Sand Creek enters the shallow aquifer through the sandy bed of the Creek. Values for ABS in excess of the recommended limits of 0.5 mg/l set forth in the U. S. Public Health Service Drinking Water Standards were found in shallow well sources of public water supply systems operated by South Adams Water District and Town and Country Mutual Water Company.

Shallow wells located in the immediate vicinity of the South Platte River are capable of intercepting the heavily polluted streamflow. The greatest amounts of induced infiltration by these wells occur during the heavy ground-water pumping periods of the summer months. An infiltration pond and well operated by Northwest Water Corporation are located near the confluence of Clear Creek and the South Platte River. Investigations of this public supply revealed ABS concentrations in the shallow pond and well were at the recommended limits set forth in the USPHS Drinking Water Standards.

As shown in Figure 15, significant and often excessive nitrates occur in the shallow aquifers in the lowlands of Clear Creek Valley and the main South Platte River Valley north of Denver. Portions of this figure, shown by diagonal lines, indicate areas where nitrates ranged from 20 to 45 mg/l; while the solid zones indicate areas where the nitrate concentrations exceeded 45 mg/l, which is the USPHS Drinking Water recommended limit. The sources of nitrates are attributed to the use of water-soluble


BOULDER
BOULDER CO
ADAMS CO
N
SCALE IN MILES
APRIL 1966
BRIGHTON
BARR LAKE
BROOMFIELD HEIGHTS
BOULDER CO
JEFFERSON CO
BROOMFIELD
STANDLEY LAKE
THORNTON
SOUTH PLATTE RIVER
LEYDEN CREEK
RALSTON CREEK
WESTMINSTER
DERBY
ROCKY MOUNTAIN ARSENAL
ARVADA
ADAMS CO.
DENVER CO
CLEAR CREEK
SAND CREEK
STAPLETON FIELD
GOLDEN
WHEATRIDGE
AURORA
ADAMS CO.
ARAPAHOE CO.
DENVER
JEFFERSON CO.
DENVER CO.
LAKEWOOD
LOWRY A F B
TOLLGATE CREEK
GLENDALE
CHERRY CREEK
BEAR CREEK
DENVER CO.
ARAPAHOE CO.
ENGLEWOOD
CHERRY CREEK RESERVOIR
TURKEY CREEK
MARSTON LAKE
CHERRY HILLS
LITTLETON
CHERRY CREEK
ARAPAHOE CO.
DOUGLAS CO.
DEER CREEK
PLUM CREEK
KASSLER
LOUVIERS
JEFFERSON CO.
DOUGLAS CO.
NORTH FORK
SOUTH PLATTE RIVER

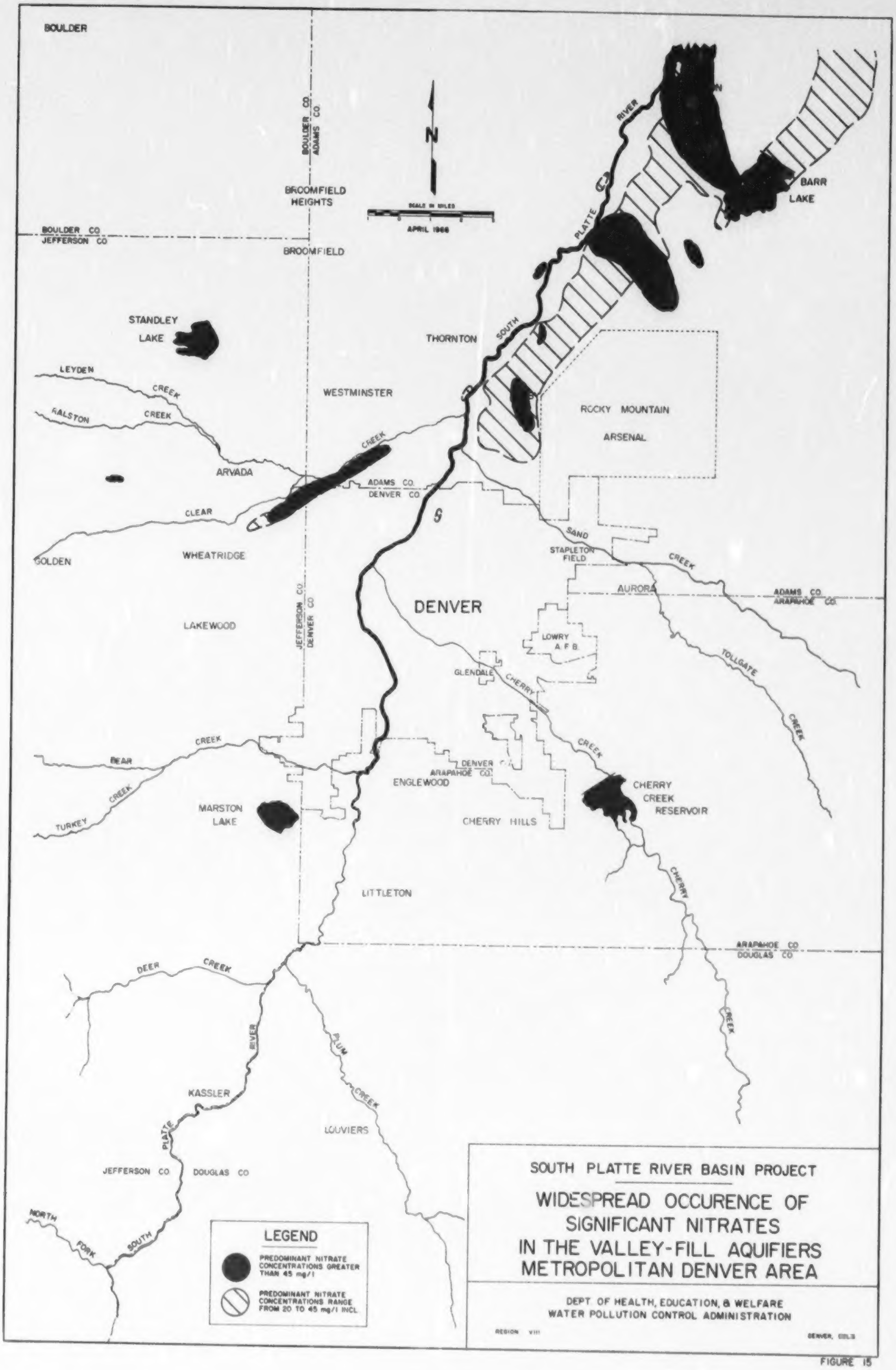
SOUTH PLATTE RIVER BASIN PROJECT

WIDESPREAD OCCURENCE OF ABS IN THE VALLEY-FILL AQUIFIERS METROPOLITAN DENVER AREA

DEPT OF HEALTH, EDUCATION, & WELFARE
WATER POLLUTION CONTROL ADMINISTRATION

REGION VIII DENVER, COLO.

FIGURE 14


BOULDER
BOULDER CO
ADAMS CO
N
SCALE IN MILES
APRIL 1966
BROOMFIELD HEIGHTS
BOULDER CO
JEFFERSON CO
BROOMFIELD
SOUTH PLATTE RIVER
BARR LAKE
STANDLEY LAKE
THORNTON
LEYDEN CREEK
RALSTON CREEK
WESTMINSTER
ROCKY MOUNTAIN ARSENAL
CREEK
ARVADA
ADAMS CO.
DENVER CO.
CLEAR
SAND CREEK
STAPLETON FIELD
GOLDEN
WHEATRIDGE
AURORA
ADAMS CO.
ARAPAHOE CO.
DENVER
JEFFERSON CO.
DENVER CO.
LAKEWOOD
LOWRY A.F.B.
GLENDALE
CHERRY CREEK
TOLLGATE CREEK
BEAR CREEK
TURKEY CREEK
DENVER CO.
ARAPAHOE CO.
ENGLEWOOD
CHERRY CREEK RESERVOIR
MARSTON LAKE
CHERRY HILLS
CHERRY CREEK
LITTLETON
ARAPAHOE CO
DOUGLAS CO
DEER CREEK
RIVER
PLUM CREEK
KASSLER
LOUVIERS
PLATTE
JEFFERSON CO
DOUGLAS CO
NORTH FORK SOUTH
LEGEND
● PREDOMINANT NITRATE CONCENTRATIONS GREATER THAN 45 mg/l
⊘ PREDOMINANT NITRATE CONCENTRATIONS RANGE FROM 20 TO 45 mg/l INCL.

SOUTH PLATTE RIVER BASIN PROJECT

WIDESPREAD OCCURENCE OF
SIGNIFICANT NITRATES
IN THE VALLEY-FILL AQUIFIERS
METROPOLITAN DENVER AREA

DEPT OF HEALTH, EDUCATION, & WELFARE
WATER POLLUTION CONTROL ADMINISTRATION

REGION VIII

DENVER, COLO

FIGURE 15

chemical fertilizers, sewage-laden recharge waters, and possibly from feedlot operations. Nitrate concentrations in the shallow aquifers of lower Clear Creek and the main valley commonly exceed 20 mg/l and are as high as 96 mg/l. Two shallow wells owned by the South Adams Water and Sanitation District, and all wells supplying the City of Brighton yield waters containing nitrate concentrations in excess of 45 mg/l, and are considered dangerous when used for infant feeding.

Much of the shallow aquifer in lower Sand Creek valley is contaminated by seepage of petroleum wastes discharged into unlined settling ponds or directly into Sand Creek. Evidence of oil contamination in wells utilized by the Town and Country Mutual Water Company in Commerce City as a source of public water supply, were first detected in 1957. Samples from these wells in 1964 indicate the situation has not changed.

In addition to public water supply, a large number of shallow wells are used for individual water supply, irrigation, industrial, and commercial purposes and stock-watering. Many of these wells were also found to be contaminated by ABS and nitrates and are located generally within the affected areas shown previously.

The Rocky Mountain Arsenal contamination incident illustrates the widespread damage that can result from disposing of wastes without first considering the hydraulic connection between surface flows and the underlying unconfined aquifer. During the period of 1943-1955, chemical wastes at the Arsenal were conveyed in unlined ditches and retained in unlined holding ponds. Most of the wastes percolated directly into the shallow and moved slowly downgradient in a general northwesterly direction toward the South Platte River. The present area of ground-water contamination resulting from excessive chloride concentrations covers approximately 12 square miles. In portions of this affected area, additional contamination is found, including excessive concentrations of fluoride, arsenic, herbicides, and pesticides. Damages to crops and domestic and irrigation water supplies have occurred. The shallow aquifer in this locality will very likely remain contaminated for many decades in the future.

Detailed investigations of the effects and extent of this contamination have been conducted by many agencies. The Colorado State Department of Public Health, in cooperation with the Tri-County Health Department, and the Rocky Mountain Arsenal are maintaining well-monitoring programs by means of periodic sampling for the purpose of keeping currently informed on direction and rate of movement of the contaminated ground water. Rocky Mountain Arsenal has abandoned the use of unlined ditches and holding pond and discharges all industrial wastes to a 96-acre asphalt-lined reservoir. The reservoir liquids are removed by evaporation and have been injected into a deep underground disposal well.

The City of Brighton is greatly concerned about the danger to its water supply because their shallow well field lies approximately five miles north of the contaminated zone. The possibility of Arsenal-contaminated ground water moving directly into the City of Brighton's well field is remote at this time. Most of the contaminated water is moving northwest of the Arsenal toward the South Platte River, the direction of the natural hydraulic gradient in the shallow aquifer.

However, the contaminated zone has spread slowly northward approximately three-quarters of a mile covering approximately three square miles, since 1955. The northward movement of contaminated water is due largely to local changes in the hydraulic gradient caused by the seasonal pumping of irrigation wells located immediately north of the zone. Withdrawals from the shallow aquifer should be carefully controlled near the present boundary of the contaminated zone in order to minimize further expansion of the contaminated zone.

It is evident that widespread pollution of the shallow, unconfined aquifers in the Denver Metropolitan area has impaired the usefulness of large quantities of water for public supply and domestic purposes. Unfortunately, these existing conditions will persist for many decades, even after sources of pollution have been eliminated. Adequate measures should be undertaken to: 1) preserve and protect the existing areas where good quality ground water is found; 2) improve the quality of ground water in the presently contaminated areas by ceasing waste discharges into the aquifer, and 3) provide a monitoring program throughout areas where the shallow aquifer is presently contaminated by ABS, nitrates and oil.

Municipal Water Supplies

During the period June, 1964 to December, 1965 the Project conducted an investigation to evaluate the quality of municipal water supplies in the Denver Metropolitan area. The objective of this program was to determine to what extent, if any, pollution now present in the South Platte River, its tributaries, and the shallow ground-water aquifer might affect these sources of water. The study included a review of available background data, an inspection of public water systems to include the source, detention reservoirs and treatment facilities in terms of adequacy and operation, and a sampling program to determine both chemical and bacteriological quality. This work was conducted in close cooperation with the Tri-County Health Department and the Colorado State Department of Public Health.

Based upon a review of existing data, obtained principally from the Colorado State Department of Public Health and Project inspection of municipal water supply source and treatment facilities, a list of twenty agencies which supply and treat water for public use was compiled. In the Denver Metropolitan area nearly 70 percent of all public water is supplied by the Denver Water Board. The Denver trans-mountain diversions have accounted for 30 to 50 percent of the total supply over the last 10 years.

The raw water obtained by the Denver Water Board is subjected to adequate treatment and is considered in compliance with USPHS Drinking Water Standards. It should be noted that no physical connections are permitted in distribution facilities between the Denver Water Board supply and water systems supplied by other sources.

The remainder of the public water supply systems in the Denver Metropolitan area are operated by municipalities, special districts, and private enterprise. Sources of supply for these agencies are various irrigation ditches originating in Clear Creek, Bear Creek, and the South Platte River, direct withdrawal from the South Platte River and Bear Creek, infiltration facilities near the South Platte River and Clear Creek and a number of wells in the shallow alluvium near the South Platte River and its tributaries. The location of various surface and infiltration sources of supply and significant waste discharges is shown in Figure 16. The location of shallow wells or well fields used for public supply and significant waste discharges is shown in Figure 17.

The quality of finished water, exclusive of the Denver Water Board, varies with the demand and the adequacy of treatment provided. Although distribution system samples of selected supplies revealed no bacterial contamination, any interruption or bypass of a water treatment facility, particularly during periods of heavy demand, could introduce contamination into the distribution system. The surface water sources of supply from Clear Creek are heavily polluted, constituting a health hazard to the consumer. In the report entitled "Metropolitan Water Supply," by the Inter-County Regional Planning Commission, dated May, 1965 it was stated that a plant used to treat water from Clear Creek and operated by the City of Arvada had been abandoned due to poor quality of the water. The systems which utilize surface water from Clear Creek and the South Platte River provide detention ponds in order to lessen the turbidity and odor associated with the raw water. The lack of sufficient coagulation and settling basins associated with some water treatment plants could permit the passage of contamination into distribution systems, particularly during periods of heavy demand. In addition, the lack of duplicate chlorine feeders increases the hazard of bacteriological contamination when this equipment is out of service.

In many instances, concentrations of ABS, total dissolved solids, sulfate, iron, manganese, oil, and nitrate in wells in the North Denver-Brighton area exceeded recommended limits of the USPHS Drinking Water Standards. Although the nitrate concentrations can be attributed, in part, to agricultural activities, the ABS and oil are associated with domestic and industrial wastes. A case of methemoglobinemia, attributable to excessive nitrates, occurred in Brighton in 1962.

The projected growth of the Denver Metropolitan area with the associated future needs for additional municipal water supplies has been outlined in the Metropolitan Water Study sponsored by the Inter-County Regional Planning Commission. It was estimated by the Inter-County Commission that the present use of 250,000 AF in the Metro area will increase to 450,000 AF in 1980. This expansion will require new sources of supply and additional provisions for water treatment.

SURFACE AND INFILTRATION SOURCES OF PUBLIC WATER SUPPLY DENVER METRO AREA
JULY 1965

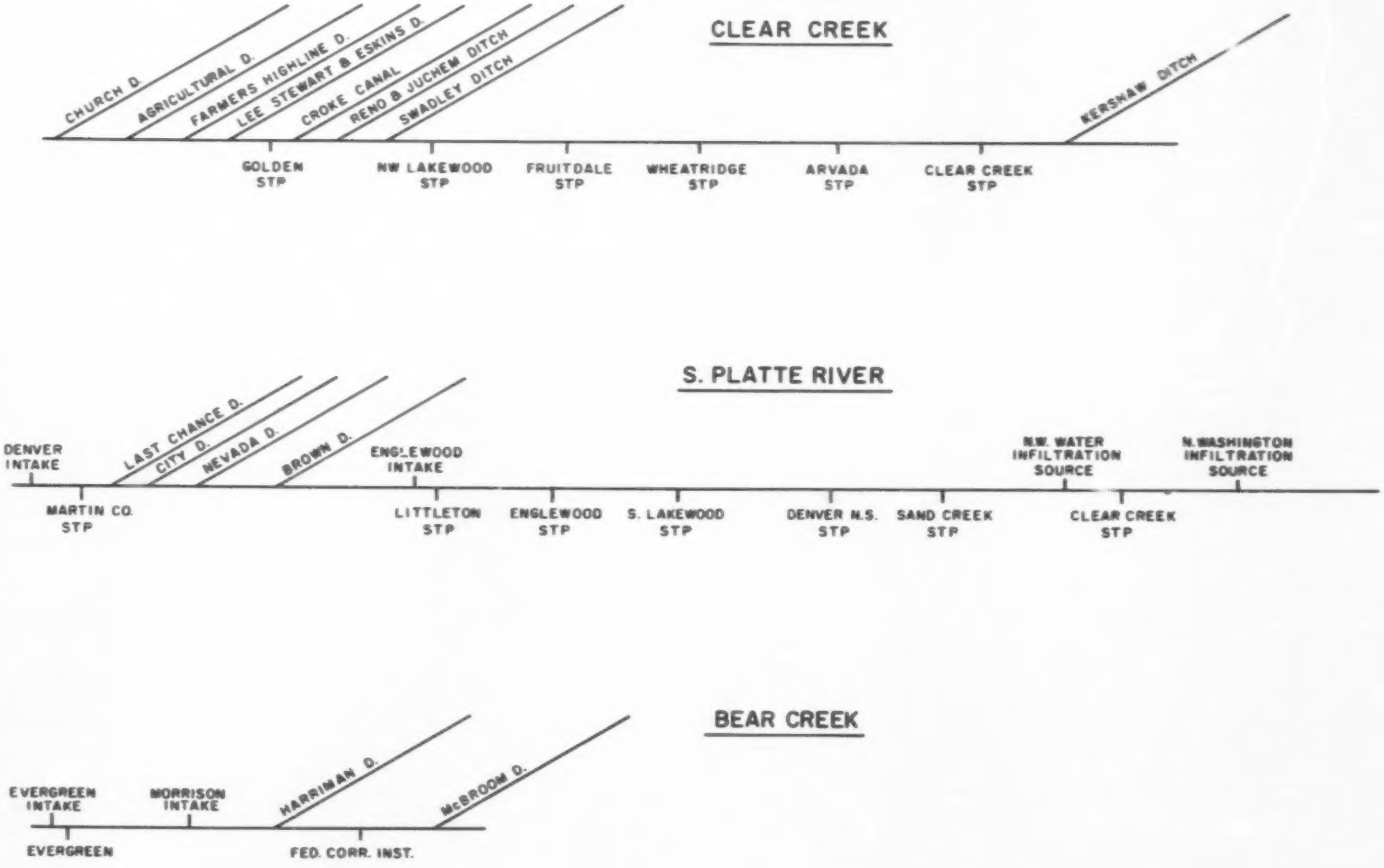
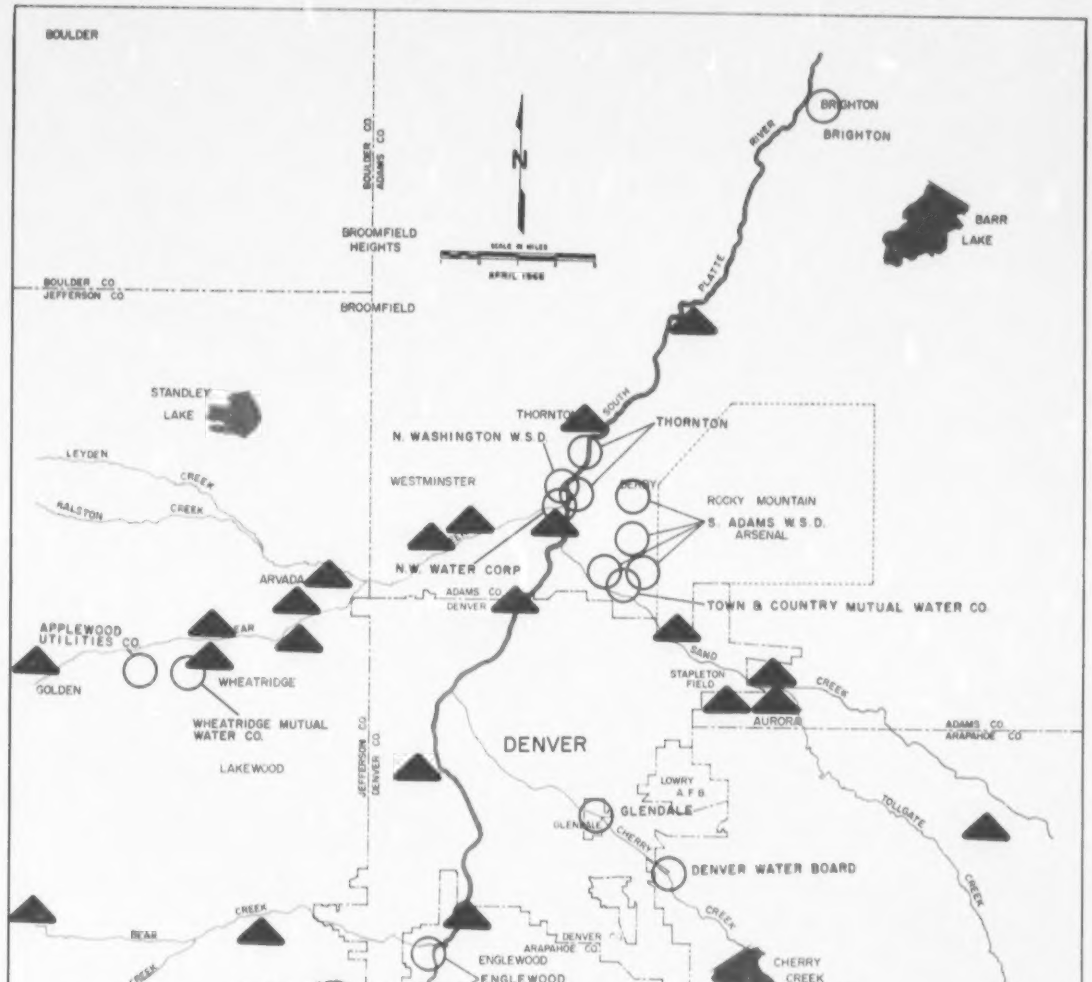

CLEAR CREEK
CHURCH D.
AGRICULTURAL D.
FARMERS HIGHLINE D.
LEE STEWART & ESKINS D.
CROKE CANAL
RENO & JUCHEM DITCH
SWADLEY DITCH
GOLDEN STP
NW LAKEWOOD STP
FRUITDALE STP
WHEATRIDGE STP
ARVADA STP
CLEAR CREEK STP
KERSHAW DITCH
S. PLATTE RIVER
DENVER INTAKE
MARTIN CO. STP
LAST CHANCE D.
CITY D.
NEVADA D.
BROWN D.
ENGLEWOOD INTAKE
LITTLETON STP
ENGLEWOOD STP
S. LAKEWOOD STP
DENVER N.S. STP
SAND CREEK STP
N.W. WATER INFILTRATION SOURCE
CLEAR CREEK STP
N. WASHINGTON INFILTRATION SOURCE
BEAR CREEK
EVERGREEN INTAKE
EVERGREEN
MORRISON INTAKE
HARRIMAN D.
FED. CORR. INST.
McBROOM D.

FIGURE 16


BOULDER
BOULDER CO
ADAMS CO
BROOMFIELD HEIGHTS
N
SCALE IN MILES
APRIL 1966
BOULDER CO
JEFFERSON CO
BROOMFIELD
BRIGHTON
BRIGHTON
BARR LAKE
SOUTH PLATTE RIVER
STANDLEY LAKE
THORNTON
THORNTON
N. WASHINGTON W.S.D.
WESTMINSTER
DERBY
ROCKY MOUNTAIN ARSENAL
S. ADAMS W.S.D.
LEYDEN CREEK
RALSTON CREEK
CLEAR CREEK
N.W. WATER CORP
ARVADA
ADAMS CO
DENVER
TOWN & COUNTRY MUTUAL WATER CO.
APPLEWOOD UTILITIES CO.
GOLDEN
WHEATRIDGE
WHEATRIDGE MUTUAL WATER CO.
LAKEWOOD
SAND CREEK
STAPLETON FIELD
AURORA
ADAMS CO
ARAPAHOE CO
JEFFERSON CO
DENVER CO
DENVER
LOWRY A F B
GLENDALE
GLENDALE
TOLLGATE CREEK
CHERRY CREEK
DENVER WATER BOARD
BEAR CREEK
TURKEY CREEK
DENVER CO
ARAPAHOE CO
ENGLEWOOD
ENGLEWOOD
MARSTON LAKE
CHERRY HILLS
CHERRY CREEK RESERVOIR
LITTLETON
LITTLETON
AURORA
ARAPAHOE CO
DOUGLAS CO
DEER CREEK
PLUM CREEK
KASSLER
LOUVIERS
DENVER WATER BOARD
JEFFERSON CO
DOUGLAS CO
NORTH FORK SOUTH PLATTE RIVER
LEGEND
WELL FIELD
SEWAGE TREATMENT PLANT

SOUTH PLATTE RIVER BASIN PROJECT

PUBLIC WATER SUPPLY SHALLOW WELL FIELDS AND SEWAGE TREATMENT PLANTS METROPOLITAN DENVER AREA

DEPT. OF HEALTH, EDUCATION, & WELFARE
WATER POLLUTION CONTROL ADMINISTRATION

REGION VIII DENVER, COLO.

FIGURE 17

MIDDLE AND LOWER BASIN

Barr Lake

Barr Lake is an artificial impoundment owned and operated by the Farmers Reservoir and Irrigation Company for the storage of irrigation water. The Lake is approximately 14 miles northeast of Denver; has a full pool surface area of 1,870 acres, a maximum depth of 42 feet, and a maximum volume of 33,000 acre-feet. The Lake is normally filled during the months of November through April by water diverted from the South Platte River through the Burlington-O'Brian Canal, a distance of 17 miles. Water is normally released from the Lake for irrigation during the period from May through September. More detailed information is contained in the Project report entitled "Barr Lake and Its Odor Relationships."

Over the years there have been numerous complaints of odors by the residents of the City of Brighton and vicinity. Brighton is located 2.7 miles northwest of Barr Lake. These odors have been attributed to Barr Lake due to the organic loading imposed on this Lake through the incomplete treatment of Denver's sewage. The point of diversion for the Burlington-O'Brian Canal is immediately downstream from the Denver Northside Sewage Treatment Plant discharge to the South Platte River.

Several studies have been made on the situation, including a Public Health Service investigation in 1948-50, a Colorado State Health Department report in 1956, and a study by Professor Ross McKinney of the University of Kansas in 1963. Studies by the South Platte River Basin Project began in March of 1964 and continued through May of 1965.

The primary source of pollution in the water diverted to Barr Lake is the partially treated sewage discharge from the Denver Northside Sewage Treatment Plant. Discharge of organics from this source is well beyond the assimilative capacity of the South Platte River to sufficiently handle this waste. Pollution is particularly severe in the winter during periods of low streamflow when the flow of Denver effluent exceeds the natural flow of the stream and much of the water is diverted for storage in Barr Lake. Since the Denver Northside Treatment Plant discharges partially treated sewage, digester supernatant, and digesting sludge to the River, the Burlington-O'Brian Canal becomes quickly devoid of dissolved oxygen and releases a septic stream into Barr Lake at practically all times.

Barr Lake is filled primarily during the non-irrigation season when water temperatures are low and the biota are semi-dormant. After the ice leaves and the Lake commences to warm in the spring, anaerobic bacterial decomposition of the organic material accelerates and increased quantities of hydrogen sulfide are produced. Algal activity remains at a low level because of cold water tempteratures and the lack of light penetration due to a relatively high concentration of suspended solids in the Lake. It is probable the odors may be concentrated in, and carried from the Lake during this period when atmospheric inversions are present and there is a breeze off the Lake. Based on operating experiences with typical waste stabilization ponds in areas of winter ice cover, Barr Lake, under present conditions, may be expected to develop odor for a period of 30 to 60 days following ice-melt.

During the late spring and summer, with increasing water temperatures and water clarity resulting from microbiological action, algae begin to appear in large numbers and produce enough oxygen through photosynthesis to help maintain the surface water of the Lake in an aerobic condition with the absence of odor. In the autumn as water temperatures cool, with a nearly empty Lake that is being refilled with heavily polluted water, there once more exists a condition for odor production until the water temperatures drop to the freezing level.

Barr Lake provides a rather effective purification system, comparable in many respects with a waste stabilization pond. Sludge deposits in the Lake are minimal and when examined were largely digested and normal for an eutrophic lake.

From an aesthetic standpoint, the odors produced by Barr Lake have been intolerable at times. Severe odors in the immediate vicinity of the Lake were verified by Project personnel during the spring of both 1965 and 1965. There were virtually no odors at other times of the year in the vicinity of the Lake. At Brighton odors were apparently not detected as originating from Barr Lake during any part of the Project study period. It should be noted that odors in the Brighton area may originate from a number of sources other than Barr Lake, including the Gates-Cyclo waste lagoon, various irrigation canals which carry polluted South Platte River water, and several feedlots located north and south of Brighton.

Following completion of the MDSDD#1 Treatment Plant in late 1966, the average organic waste loading on Barr Lake should be reduced to 30 percent or less of the previous rate of loading and odor production cut to a minimum. In the future Barr Lake could have odor production for a short period following the ice-melt. This period would probably last from one to two weeks, or until photosynthesis is well established. In the fall there should not be a recurrence of odor conditions as in the past because of a reduced organic loading to the Lake and continued photosynthesis. The Lake should show improvement in the spring of 1967, following completion of the Metro Sewage Treatment Plant. A secondary cause of odor from Barr Lake could arise in the future from the decay of large amounts of algae driven ashore by wind action. Odors may also come from the Lake, but should not be intense and may be diminished by use of copper sulfate or other algae control measures. In addition, littoral vegetation should be kept from the Lake by spraying or cutting when the Lake is down.

Recommendations in this report which include: 1) the delivery of a high quality effluent from the Metro plant with a BOD removal of at least 92 percent; and 2) adequate treatment of all wastes entering the South Platte River above the Burlington-O'Brian Canal, will afford considerable improvement in the odor problem.

Insect Vector Problems

Vector problems within the Basin were evaluated by Project personnel during the spring and summer of 1964. A review was made of past vector studies conducted over the area by the Disease Ecology Section, Communicable Disease Center, Greeley, Colorado, and other health agencies within the Basin. Also, a mosquito survey and general field observations were made within the Denver Metropolitan area by the Project and CDC personnel during the summer of 1964. More detailed information is contained in the Project report entitled, "Significant Vector Problems in the South Platte River Basin."

Essentially, the vector problems within the Basin involve mosquitoes, rats, and flies. Of considerable public health significance are the diseases transmitted by mosquitoes and rat-fleas, such as encephalitis and plague, respectively. Flies also transmit a wide range of enteric diseases. Beyond the disease-causing potential, mosquitoes, rats, and flies are responsible for substantial economic losses and require considerable expenditures for their elimination and control.

Significant vector populations of mosquitoes, rats, and flies do exist in the Basin and constitute a serious public health hazard. These vectors, especially mosquitoes and rats, are directly associated with the organic pollution present in waters of the Basin. This pollution is instrumental in creating and supporting the present high population levels of disease-carrying vectors, particularly in the Denver Metropolitan area.

Ideal mosquito-breeding grounds exist throughout the Basin. Improper irrigation practices create many seeps and standing pools of water in which mosquitoes breed readily. In addition, the many sloughs and backwaters along the river bottoms provide ideal areas for mosquito production. The presence of heavy organic pollution from sewage and industrial wastes in many of these waters enhances the environment for excessive production of those species of mosquitoes associated with the transmission of encephalitis. Encephalitis has occurred sporadically in the Basin with the most recent outbreaks of note occurring in 1957 and 1964.

Certain areas within the Basin have serious rat infestation problems. The most notable of these is the concentration of a large rat population along the banks of the South Platte River and its tributaries in the northern sector of Metropolitan Denver. Rats are semi-aquatic by nature, and adapt readily to life along river banks -- particularly where brush and trash provide good cover and harborage. In this case an excellent food supply is readily available from the heavy load of floating organic pollution present in the South Platte River and its tributaries. The presence of this highly concentrated rat population constitutes a potential plague threat to area citizens.

Several species of biting and non-biting gnats and black flies breed extensively in the waters of the Basin. These insects cause severe human annoyance and occasionally are involved in disease transmission. The presence of organic pollution in the breeding waters creates a favorable larval environment and results in increased production of these insects.

The most serious housefly problems in the Basin stem from the extensive breeding of flies in the accumulated manure piles associated with cattle feedlots and stockyards, and in the garbage spread for the feeding of hogs at various hog farms. These substances all provide the type of warm, moist organic environment required for fly larvae development.

Future vector population levels will remain high as long as significant quantities of organic pollutants are discharged to the waters of the Basin. Reduction of present vector populations will be accomplished through the abatement or elimination of the gross organic pollution now being discharged to receiving streams throughout the Basin, as recommended in this Report.

Feedlot Wastes

There are about 40 cattle feedlots in the South Platte River Basin which routinely feed more than 500 cattle at any one time. The total cattle population on these feedlots ranges from 200,000 to 270,000 animals. Of these feedlots, nine containing approximately 75,000 cattle with a population equivalent of 1.2 million contribute pollution directly to the South Platte River and its tributaries. Feedlot investigations by the Project have been underway since March 1965.

The feedlots create both odor and water pollution problems. These odors are particularly severe in Denver, Brighton, Greeley, and Sterling.

Pollution of surface watercourses by feedlot drainage has been observed in the Basin and is due to the following practices and conditions:

1. Open channels and pipes used for direct gravity drainage from feedlots into watercourses.
2. Intermittently pumped discharges into watercourses from collecting sumps and low field areas.
3. Direct surface runoff from feedlots adjacent to watercourses during periods of appreciable rainfall.
4. Shallow infiltration from feedlots into adjacent watercourses during wet weather periods.

In other river basins where these wastes have been discharged as slugs into small watercourses, fish kills have occurred.

Disease hazards are associated with the bacteriological pollution of surface streams by swine and beef cattle manure in the South Platte River Basin. Such diseases can be transmitted:

1. Animal to animal.
    a. Downstream animal drinking.
2. Animal to man.
    a. Downstream swimming and water-contact sports.
    b. Pollution of irrigated vegetables, such as lettuce and celery, by irrigation water from polluted streams.

c. Occupational hazards to cropland workers from manure in polluted irrigation water.

The more significant water-borne diseases involving swine, beef cattle and man are considered to be anthrax, leptospirosis and salmonellosis. No epidemiological investigation of the incidence of zoonotic diseases in man and animal has been performed by the Project. It is considered, however, that opportunities for disease transmission from animal to animal are greater than from animal to man, due to the animal drinking water factor and because stream water in the Basin, at the present time, is not used directly for human consumption below these waste sources.

Pollution by oxygen demanding materials in feedlot manure appears to be limited to surface water resources. But, in addition, feedlots may add substantial amounts of nitrates to the ground water in localized areas. Pollution of ground water by nitrogen compounds is already a problem in parts of the aquifer in the Basin, due mainly to the recycling of irrigation water and the use of water-soluble chemical fertilizers.

Pollution of surface water resources caused by feedlot wastes is now occurring at several places throughout the South Platte River Basin. Feedlot drainage is presently being pumped, or piped directly to surface streams, and in other cases overland surface drainage from feedlots is reaching the streams.

Basically, the environmental control of feedlot waste problems includes the prevention of surface runoff pollution, ground-water pollution, odors, and housefly production in the manure.

Sugar Beet Processing Wastes

Water pollution caused by discharge of sugar beet processing wastes in the South Platte River Basin is of serious concern. It is recognized that Great Western Sugar Company, which owns and operates all plants within the Basin, was successful in the 1940's in greatly reducing their waste loads. Since that time the industry has made progress towards further reduction, but there also has been an increase in the total amount of beets processed. The industry, in 1949, was found to discharge a total waste from twelve plants equal to a population equivalent of raw sewage from 4.1 million people. Discounting two plants that have ceased operation, the wastes from the ten remaining plants, which are those operating today, were equal, in 1949, to a population equivalent of 3.1 million people. In 1963-1965 these same ten plants were discharging wastes equivalent to 2.3 million people, or 25 percent reduction from 1949. Although there has been reduction in waste load, the remaining wastes from the beet sugar industry to Basin streams are greater at the present time than the raw wastes which could be discharged by the entire population in the State of Colorado. Sugar beet waste pollution adversely affects more than 215 miles of stream which represents about 40 percent of primary stream mileage within the South Platte River Basin.

The water quality criteria for clean water in the middle and lower portions of the South Platte River Basin are once again mentioned to give perspective to this problem. These criteria consist of a maximum allowable content of 15 mg/l 5-day BOD, and no more than 5,000 total coliform bacteria/100 ml, and 1,000 fecal coliform bacteria/100 ml in the stream waters. Also, the dissolved oxygen content of these waters is not permitted to be less than 4 mg/1. The quality of stream waters during the sugar beet processing seasons of 1963 through 1965 are described for five major areas: 1) St. Vrain Creek below Longmont; 2) the Big Thompson River below Loveland; 3) the Cache la Poudre River below Windsor; 4) the South Platte River from Brighton to Kersey; and 5) the South Platte River from Fort Morgan to the Colorado-Nebraska Stateline.

St. Vrain Creek - In St. Vrain Creek, major waste discharges are from the sugar beet mill, the Kuner-Empson cannery and the municipal sewage treatment plant, all of which are located at Longmont, Colorado, and the City of Boulder sewage treatment plant. Figure 18 shows the results of two studies. In January 1964, St. Vrain Creek was sampled near its mouth. In November 1965 the same stream was sampled in the Longmont area.

During the 1965 study, 5-day BOD increased from 9 mg/1 in the stream directly above the Longmont sugar mill discharge, to 33 mg/1 at a point four miles downstream. The waste flow from the mill contributed 240,000 P.E. of BOD to the stream. Only part of the BOD from the mill reached the downstream sampling point because of extensive settling of waste material directly below the mill outfall. Bottom sludge deposits degrade the stream by limiting or destroying bottom organisms, destroying aquatic plants and other food matter for fish life, extracting oxygen from the overlying waters, and creating foul-smelling and unsightly conditions in the stream as the organic matter in the sludge decays. Even with the majority of wastes settling out, the BOD at the station downstream from Longmont was more than twice the allowable objective of 15 mg/1.

QUALITY of ST VRAIN CREEK WATERS
January, 1964 and November, 1965

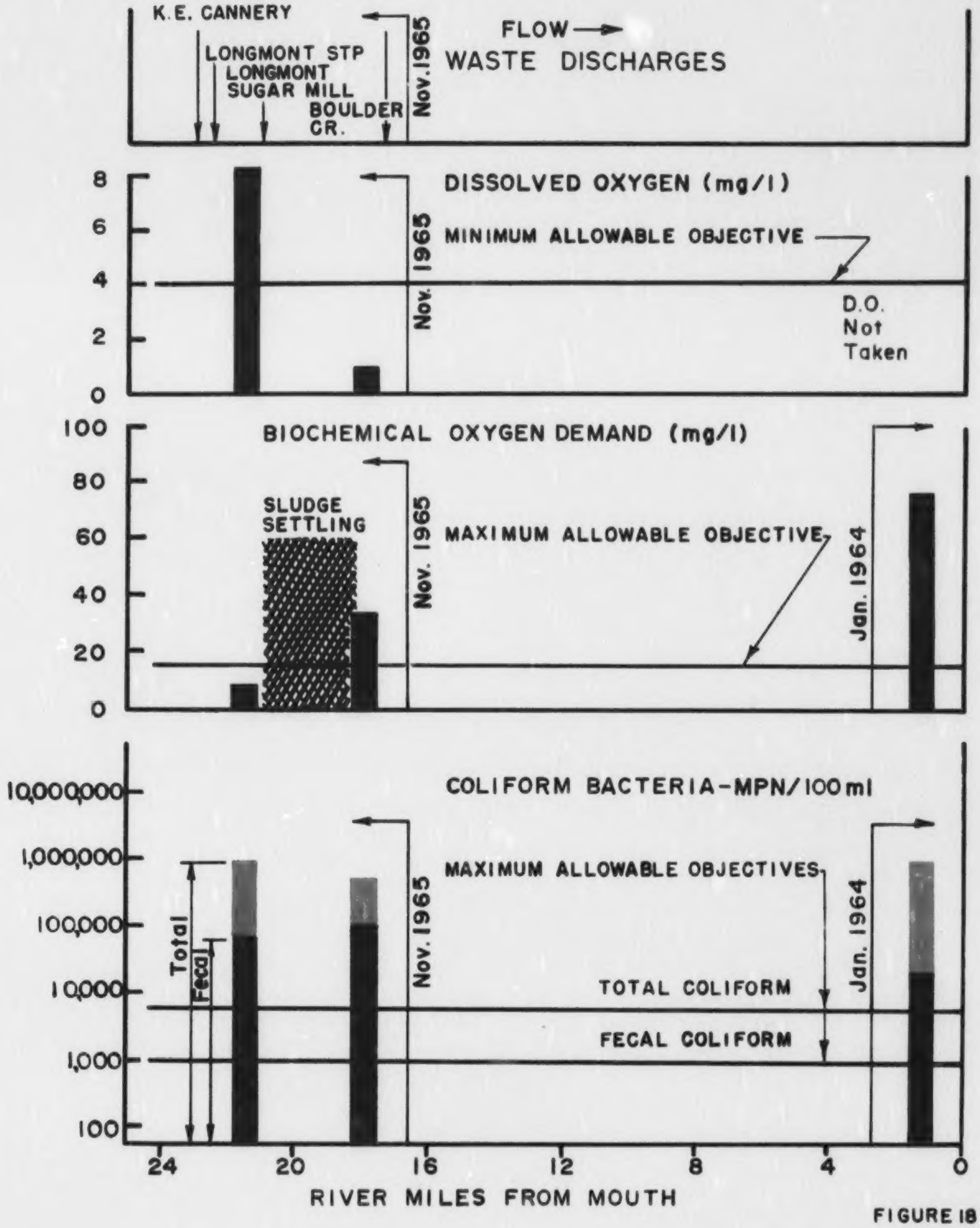


FIGURE 18

The stream above the mill with 9 mg/l BOD was definitely affected by waste load from the Longmont sewage treatment plant. Other Project studies show 12,000 P.E. of BOD waste load from the municipal treatment plant and up to 60,000 P.E. of waste load from the Longmont cannery when it is operating. In November 1965 the sugar beet mill accounted for more than 90 percent of the organic waste load to the stream in the Longmont area.

The dissolved oxygen of the stream was near saturation above the mill, but four miles below it averaged only 0.7 mg/l. There was also, at certain times, total depletion of oxygen. This caused the stream below Longmont to be in a state of severe degradation. In addition, discharges from the sugar mill and the Longmont municipal sewage plant resulted in coliform densities approximately 160 times, and 94 times respectively, the allowable objective of 5,000/100 ml for total coliform and 1,000/100 ml for fecal coliform.

The January 1964 results at the mouth of St. Vrain Creek indicate that severe degradation does occur over the entire twenty-two miles of stream below Longmont. The City of Boulder is another contributor of waste load. Nevertheless, in January 1964 the large majority of waste load at the mouth of St. Vrain Creek was still originating from the Longmont sugar mill. Since the waste load in the lower reaches of the stream approximated 220,000 P.E. of BOD in January 1964, there was little settling of wastes in the stream at this time. However, in addition to St. Vrain Creek being adversely affected, the South Platte River was also undergoing change as a result of heavy waste discharged into it. In January 1964 St. Vrain Creek, at its mouth, was found to contain 74 mg/l BOD, 790,000 total coliform bacterial/100 ml, and 23,000 fecal coliform/100 ml. These values exceed allowable objectives by 4,157, and 22 times respectively.

Big Thompson River - The second major area includes the Big Thompson River below Loveland and also the Little Thompson River as its main tributary stream. Major waste discharges are from the Loveland sugar mill, the Loveland municipal sewage treatment plant, and the Monosodium-Glutamate sugar recovery plant at Johnstown on the Little Thompson River. There are a number of small towns in the area, some of which need better sewage treatment, but the waste residual from all of these towns does not appear to exceed 3,000 P.E. This is less than one percent of the total municipal and industrial wastes discharged to the two streams. Figure 19 shows the results of stream studies conducted on the lower ends of the Big Thompson and Little Thompson Rivers during January 1964, and on the Little Thompson River again in August and November of 1965.

In January 1964 the Big Thompson River was sampled 19 and 26 miles downstream of Loveland and the Little Thompson River entering between these two stations was sampled near its mouth.

In January 1964 the Big Thompson River 19 miles below Loveland carried a waste load equal to 300,000 P.E., or 25 tons of BOD per day. Of this load, two percent or less originated from the Loveland sewage treatment plant with the remainder from the sugar beet mill. The Big Thompson River at this point contained 296 mg/l of 5-day BOD. The values found exceeded allowable stream objectives by 19 times in the case of BOD, was 4 times the total coliform objective, but did not exceed the maximum allowable fecal coliform level. Supplementary

QUALITY OF BIG THOMPSON AND LITTLE THOMPSON RIVER WATERS
January 1964 & August and November 1965

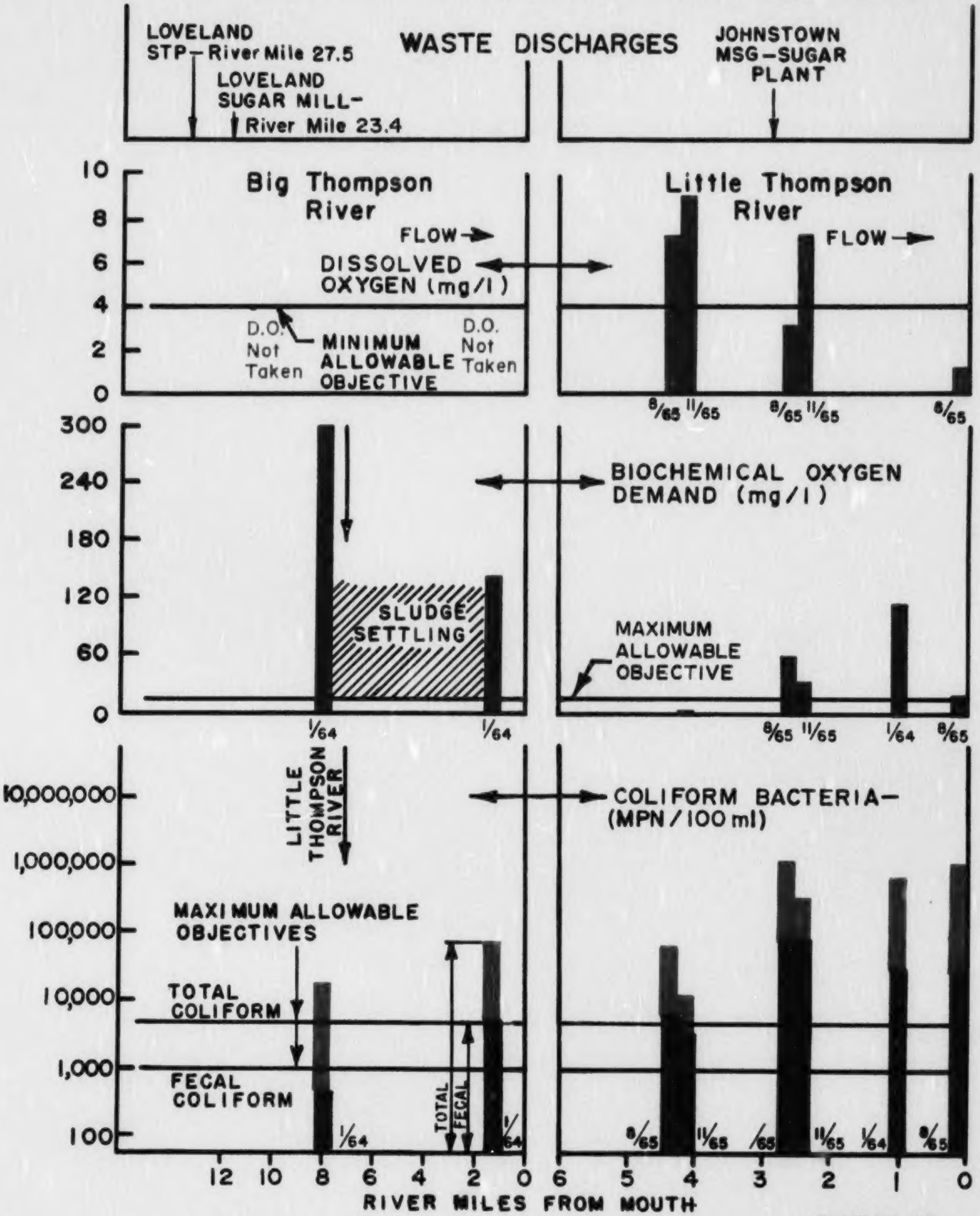


FIGURE 19

studies in this area also show extensive waste settling occurring in the River below Loveland. These sludge deposits further aggravate the extreme degradation occurring in the stream.

The Big Thompson River, at its mouth, was influenced by the inflow of the Little Thompson River at river mile 7.0. BOD concentration at the mouth decreased to 145 mg/l due to greater flow, even though the Big Thompson River was now carrying a waste load equal to 350,000 P.E. Total and fecal coliform bacteria increased to exceed the allowable objectives by 13 and 4 fold. In addition to the Big Thompson River being intensely affected by pollution for the 26 miles below Loveland, this large organic load is, in turn, dumped into the South Platte River with major consequences thereupon. These effects are discussed later.

The Little Thompson River was sampled below the Johnstown MSG sugar recovery plant in January 1964 and both above and below the plant in August and November 1965. The results are shown in Figure 19. Above Johnstown the Little Thompson River is affected by irrigation return and transfer flows, and by residual wastes from upstream communities. The dissolved oxygen content was high, from 7.1 to 9.1 mg/l, and the BOD was low at 2.8 mg/l. Because of upstream effects and rainfall occurring previous to the field survey, bacterial values were slightly higher than background. Runoff produced drainage from farm and livestock areas into the stream.

Waste effluent from the Johnstown industrial plant has a profound effect on the lower portions of the Little Thompson River. This discharge was rated at 95,000 P.E. of BOD in August 1965. After plant modifications in late summer, it was found to contain 70,000 P.E. of BOD in November 1965.

The dissolved oxygen in the stream one-half mile below the plant ranged from 3.2 to 7.2 mg/l in 1965, and at a point two miles further downstream was only 1.1 mg/l in August 1965. BOD concentration in the stream below Johnstown ranged from 22 to 114 mg/l as compared to the value of 2.8 mg/l in the stream above Johnstown. The downstream dissolved oxygen drops considerably below the allowable stream objective, and the BOD below Johnstown exceeds the objective by 50 percent up to 660 percent. Coliform bacteria from above to below Johnstown increased in the order of 6 to 110 times for total coliform and from 6 to 20 times for fecal coliform, being much in excess of allowable stream conditions.

Cache la Poudre River - The Cache la Poudre River below Windsor during the months of October through January essentially comprises an open sewer. Very large amounts of untreated and partially treated wastes which are highly putrescible are discharged by various industrial and municipal sources into the Cache la Poudre River. Subsequently, these waste loads are released into the South Platte River. The Cache la Poudre River flowing through the Greeley area during this period of the year is extremely objectionable to the visual and olfactory senses and completely unsuited for any beneficial use.

Major waste discharges are from the three sugar beet mills at Windsor, Eaton, and Greeley, the Greeley sewage treatment plant, and at the time of survey, from the Monfort Packing Company. Since late summer of 1965, waste effluents from the meat processing operations have been absorbed into the Greeley sewage treatment plant. Also, this treatment plant has been enlarged since the time of the survey.

The Cache la Poudre River was investigated in January 1964 from Windsor to the stream mouth, together with separate studies on the Windsor and Greeley sugar mill waste discharges.

Additional sampling was conducted in May 1965 on the Monfort Packing Company waste effluents, followed by studies in November 1965 on the Eaton sugar mill discharges and the quality of water existing in Eaton Draw. Both the Eaton mill and the town of Eaton release their wastes into Eaton Draw, which in turn discharges into the Cache la Poudre River within Greeley.

In January 1964 the three sugar beet mills discharged a waste load equal to the BOD found in raw sewage from a population of 1,070,000 people. In addition, the Monfort Packing Company was discharging processing wastes containing 100,000 P.E. and the Greeley municipal treatment and sewerage system, which was overloaded at that time, contributed another 25,000 P.E. of waste load to the River. The Cache la Poudre River in January 1964 was receiving a total waste load of 1,200,000 P.E. with dire consequences to the River. Results of the stream studies undertaken at that time are shown in Figure 20.

The Cache la Poudre River entering Windsor was of good quality, containing only 2 mg/l 5-day BOD, 1,100 total coliform per 100 ml, and 490 fecal coliform per 100 ml. The Windsor sewage treatment plant contributed approximately 400 P.E. of waste to the River and this was followed by 440,000 P.E. of waste load found to be coming from the Windsor sugar beet mill in January 1964. From above Windsor to a point on the River four miles below the sugar beet mill, the BOD increased 250 times to a level of 482 mg/l, total coliform bacteria increased 2,200 times to 2.4 million per 100 ml, and fecal coliform increased

22 fold to 11,000 per 100 ml. The stream below Windsor was comprised almost entirely of high-strength and readily decomposable waste from the Windsor sugar mill. The BOD concentration of 482 mg/l in the stream is one of the highest values that has been observed for any stream in the country. The buildup of sludge banks in this stretch of the River further compounds the existing problems and there is complete negation of stream values. The situation today is one of absolute degradation.

Liquid wastes in their travel down the River to Greeley are diluted by ground-water inflow but the situation still remains critical. Inside Greeley at the Fairgrounds, the stream was burdened with 199 mg/l of 5-day BOD, 220,000 total coliform bacteria/100 ml and 3,300 fecal coliform/100 ml, and somewhat surprisingly contained 3.0 mg/l of dissolved oxygen. The BOD content was 12.5 times the maximum allowable stream objective and the total coliform level was 44 times the allowable objective. This stream flows around the northern periphery of the Greeley Fairgrounds where large numbers of people, both in the summer and winter, derive satisfaction in outdoor recreation.

Through Greeley the River receives heavy waste load from the sources previously mentioned, and in addition is adversely affected by the many gravel washing operations in the area. The Eaton sugar mill was found, in November 1965, to discharge 120,000 P.E. of waste, but in January 1964 because of frozen beets and large amounts of pulp silo drainage, this waste load was equal to 450,000 population equivalents. The Greeley sugar mill in January 1964 discharged another 160,000 P.E. of waste to the Cache la Poudre River.

At the Greeley sugar beet mill, an intense hydrogen sulfide odor occurred in the vicinity of the existing waste treatment pond. Hydrogen sulfide is a real cause of concern to adjoining property owners. In

QUALITY of CACHE LA POUDRE RIVER WATERS
January 1964

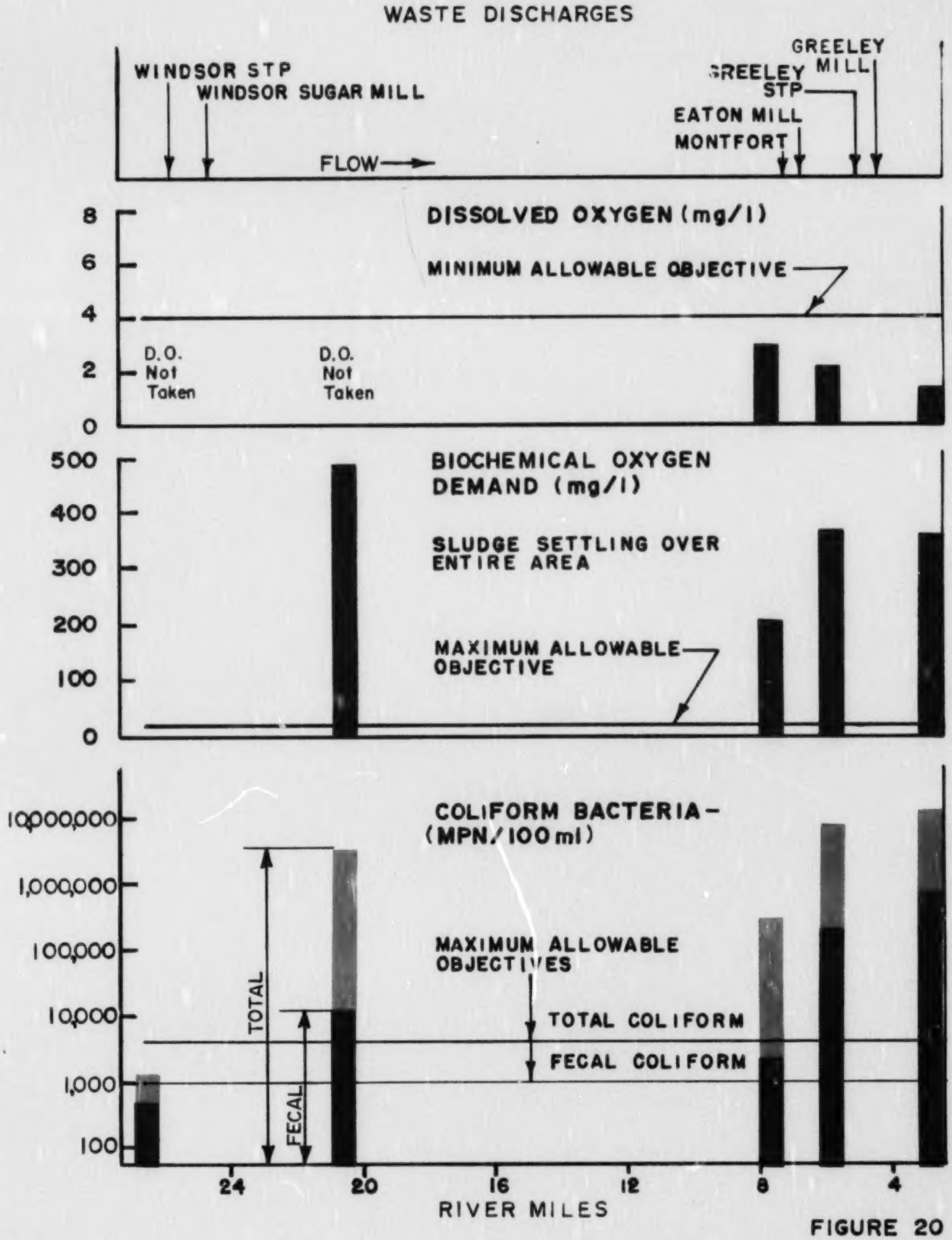


FIGURE 20

January 1964 the waste effluent discharged from the Greeley mill to the River was found to contain 27 mg/l sulfides and the River downstream showed 0.63 mg/l sulfides. This problem was caused by the high level of organic matter and sulfates in the raw water supply received by the Greeley mill from the Cache la Poudre River. This flow, after leaving the mill as process waste water, became anaerobic in the treatment pond. Under these conditions sulfates were converted to sulfides and hydrogen sulfide odors were very significant.

The pollution levels in the Cache la Poudre River from Greeley to the confluence with the South Platte River are entirely in the critical or severe degradation zone. In January 1964 from the Fairgrounds to a point two miles below Greeley, the BOD increased from 190 to 349 mg/l; the dissolved oxygen decreased from 3.0 to 1.6 mg/l with many individual values near 0.0 mg/l; total coliform bacteria increased from 220,000 to 11.0 million organisms per 100 ml; and fecal coliform bacteria increased from 3,300 to 790,000 organisms per 100 ml. The largest single waste load in January 1964 was the Eaton Draw drainway. The lower portion of the Cache la Poudre River during the wintertime is the most severe case of surface water pollution existing in the entire South Platte River Basin.

South Platte River from Brighton to Kuner, Colorado - The fourth area of study comprises the South Platte River from Brighton downstream below Greeley to Kuner, Colorado, a total stream distance of 54 miles. The South Platte River entering Brighton is at the present time heavily polluted by organic waste load from the Denver Metropolitan area. Other major waste loads are the processing effluents from the Brighton sugar mill and the heavy loads contained in the tributary streamflows entering the study area. These latter streamflows include St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River. The South Platte River serves as a massive collection system for combining these various waste loads into one. Further downstream below Kuner, large irrigation companies divert practically the total South Platte River, together with the enormous waste loads contained therein, and these flows are stored for irrigation use in the following season.

Minor waste discharges to the South Platte River from Brighton to Kuner include municipal sewage from various sources and industrial waste from the Kuner Empson cannery at Brighton. These minor discharges represent a total of 11,000 P.E. of BOD. Stream study over this circuit was carried out in January 1964 from Platteville to Kuner, and additional study was conducted in January 1965 at the Brighton sugar beet mill. The results obtained are shown in Figure 21.

The South Platte River for the entire distance of more than 75 miles from Denver to beyond Kersey is grossly polluted. The values were many times over the allowable objectives for BOD and coliform content, and except for one case, considerably below the objective of 4.0 mg/l dissolved oxygen. The severe degradation of this important reach of the River is a matter of extreme concern.

The January 1965 data shows a very large waste load of 250,000 P.E. from the Denver Metropolitan area reached Brighton. The Brighton mill, in January 1965, discharged processing effluents into the River equal to 160,000 P.E. The dissolved oxygen content of the River above the sugar mill was low at 3.1 mg/l and below the mill was further reduced to 1.7 mg/l. From above to below this waste discharge, the BOD in the River increased from 77 to 114 mg/l, total coliform bacteria increased

QUALITY OF SOUTH PLATTE RIVER WATERS
Brighton to Kuner
January, 1964 and 1965

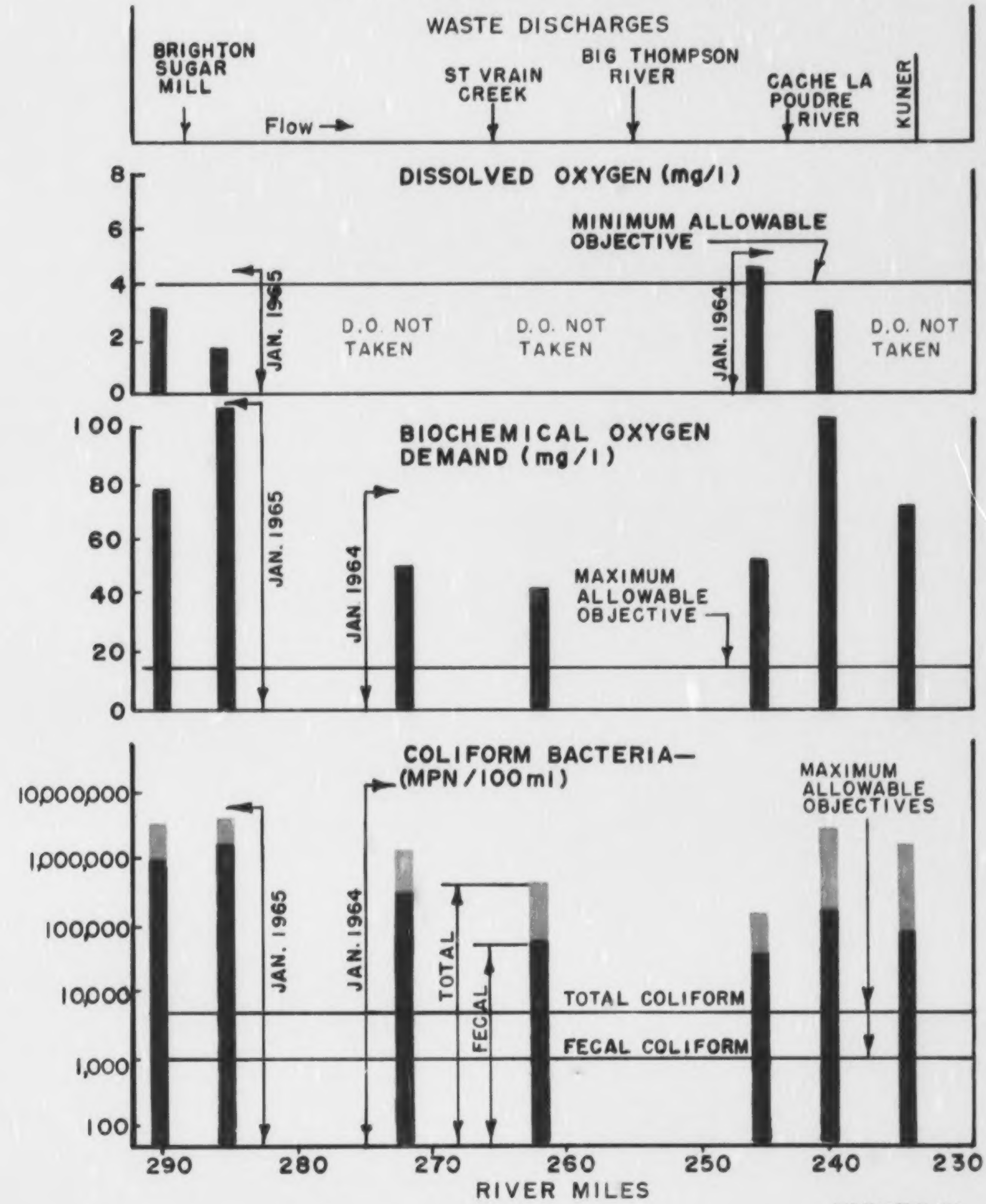


FIGURE 21

from 3.3 to 4.0 million organisms per 100 ml, and fecal coliform increased from 790,000 to 1.4 million organisms per 100 ml.

The South Platte River from Platteville to the community of Kuner was studied in January 1964. The BOD and coliform concentrations of the River upstream of Platteville decreased from the levels below Brighton. These decreases were caused by ground-water inflows and some stream assimilation. However, the observed BOD in the River above Platteville was still more than 3 times the allowable objectives and total and fecal coliform bacteria levels were 220 times and 330 times the respective bacterial stream objectives. Upstream waste loads predominated in the River down to Platteville.

Below Platteville the inflows of the three major tributaries: St Vrain Creek, the Big Thompson River, and the Cache la Poudre River determine, to a large degree, the amounts of pollution found in the South Platte River. Without these waste-laden tributary streams, the pollution levels in the South Platte River would diminish until reasonably good water quality would exist in the downstream areas of Kersey and Kuner. Instead, a different picture results. Waste loads brought in by St. Vrain Creek and the Big Thompson River sustain the level of pollution previously observed at Platteville. The Cache la Poudre River on the other hand with its very heavy waste load causes substantial increase in BOD and bacteria concentrations of the South Platte River. Respective input loads of these three tributary streams in January 1964 were 220,000 P.E., 350,000 P.E., and 890,000 P.E. The South Platte River below the Cache la Poudre was carrying a waste load of 1,370,000 P.E. which is more than the maximum load found below the Denver Metropolitan area. Thus, 65 miles downstream from Denver severe stream pollution problems are caused by sources other than large population centers. The large majority of this waste load originates from the many sugar beet mills located upstream.

The resultant BOD levels in the South Platte River between St. Vrain Creek and the Cache la Poudre River ranged from 43 to 54 mg/l; in this same stretch total coliform content was between 130,000 and 350,000 organisms per 100 ml and fecal coliform was between 22,000 and 49,000 organisms per 100 ml. The South Platte River downstream of the Cache la Poudre had a BOD range of 73 to 99 mg/l, total coliform from 1.3 to 2.4 million organisms per 100 ml, fecal coliform from 79,500 to 115,000 organisms per 100 ml, and dissolved oxygen content of 3.0 mg/l. A very large improvement in quality of the South Platte River from Brighton to Kuner is definitely needed.

South Platte River from Fort Morgan to the Stateline - The fifth and last major area is the lower South Platte River which starts at Fort Morgan and runs a distance of approximately 110 miles to the Colorado-Nebraska Stateline. There are two principal factors controlling the quality and quantity of streamflow in the lower South Platte River. These factors comprise the many diversions taking flow from the River for irrigation water storage, and the important waste discharges from the three sugar beet mills located at Fort Morgan, Sterling, and Ovid. These canal diversions can withdraw almost the entire streamflow at a given point. However, ground-water inflow fortunately plays an important role in returning water to the River and maintaining basic streamflows therein. A sampling survey was conducted in December 1963 on the South Platte from Fort Morgan to the Stateline. It was found that the three mills were discharging a total organic waste load of 550,000 P.E. to the River. Minor waste loads from the Fort Morgan, Brush, Sterling, and Julesburg sewage treatment plants totaled 10,000 P.E., which was less than two percent of the total wastes reaching the River at that time. Results of the December 1963 stream studies in the lower South Platte River are shown in Figure 22.

The South Platte River above Fort Morgan was comprised almost entirely of ground-water accretions entering upstream, and these waters contained virtually no waste load. The 5-day BOD was 2 mg/1, and total and fecal coliform bacteria were 490 and 80 organisms per 100 ml, respectively. This station provided a background upon which water quality conditions downstream could be compared.

Below the Fort Morgan sugar beet mill and the municipal waste treatment plant, the South Platte River changed in character from a clean stream to one showing definite effects from waste loads. Residual wastes were also released to the stream by the City of Brush sewage treatment plant, but still the Fort Morgan sugar mill accounted for 95 percent of the total BOD waste load added to the stream from Fort Morgan down to Sterling. The 5-day BOD value in the River between Fort Morgan and Sterling reached a maximum value of only 15 mg/1. However, it must be noted that a relatively large River flow was present in December 1963, and furthermore, BOD load was removed from the flowing waters by settling to the stream bottom. There are higher BOD values in the stream during low flow period. The South Platte River below Fort Morgan, as compared to above, showed an increase of 300 fold in total coliform and 340 fold in fecal coliform. Coliform levels downstream were many times over the allowable stream objectives.

Effects of pollution disappeared in the River some 20 miles below Fort Morgan. This was due to waste loads together with streamflow being diverted almost totally to off-site irrigation storage reservoirs. The South Platte River from Balzac to Sterling, a distance of some 22 miles, was comprised of ground-water inflow carrying little or no waste load. BOD and coliform concentrations in this stretch of stream were in the very low range.

The Sterling area contributes substantial waste to the South Platte River. The Sterling sugar beet mill discharged 250,000 P.E. of waste load to the River and another 3,000 P.E. of waste load was discharged by the Sterling municipal sewage treatment plant. Compared to Fort Morgan, the Sterling area contributed a greater waste load to the South Platte River; and further, there was less available streamflow. Consequently, the River downstream from Sterling was severely degraded. The South Platte River, 7 miles below Sterling, was found to contain 46 mg/l 5-day BOD, 2.3 million total coliform bacteria per 100 ml and 45,000 fecal coliform/100 ml. Field observations verified the presence of sludge deposits blanketing the stream bottom, which further intensify the existing pollution problems. The situation below Sterling indicates a definite need for waste abatement action. The BOD concentration was more than three times the allowable level, and bacterial concentrations were 450 times the total coliform objective and 45 times the fecal coliform objective. Large expansion of the packinghouse industry predicted in this area will further necessitate stringent control of all wastes discharged to the River at Sterling.

In December 1963, the South Platte River, 29 and 50 miles below Sterling, showed reasonably good recovery from upstream pollution loads

QUALITY OF SOUTH PLATTE RIVER WATERS
Fort Morgan to State Line
December, 1963

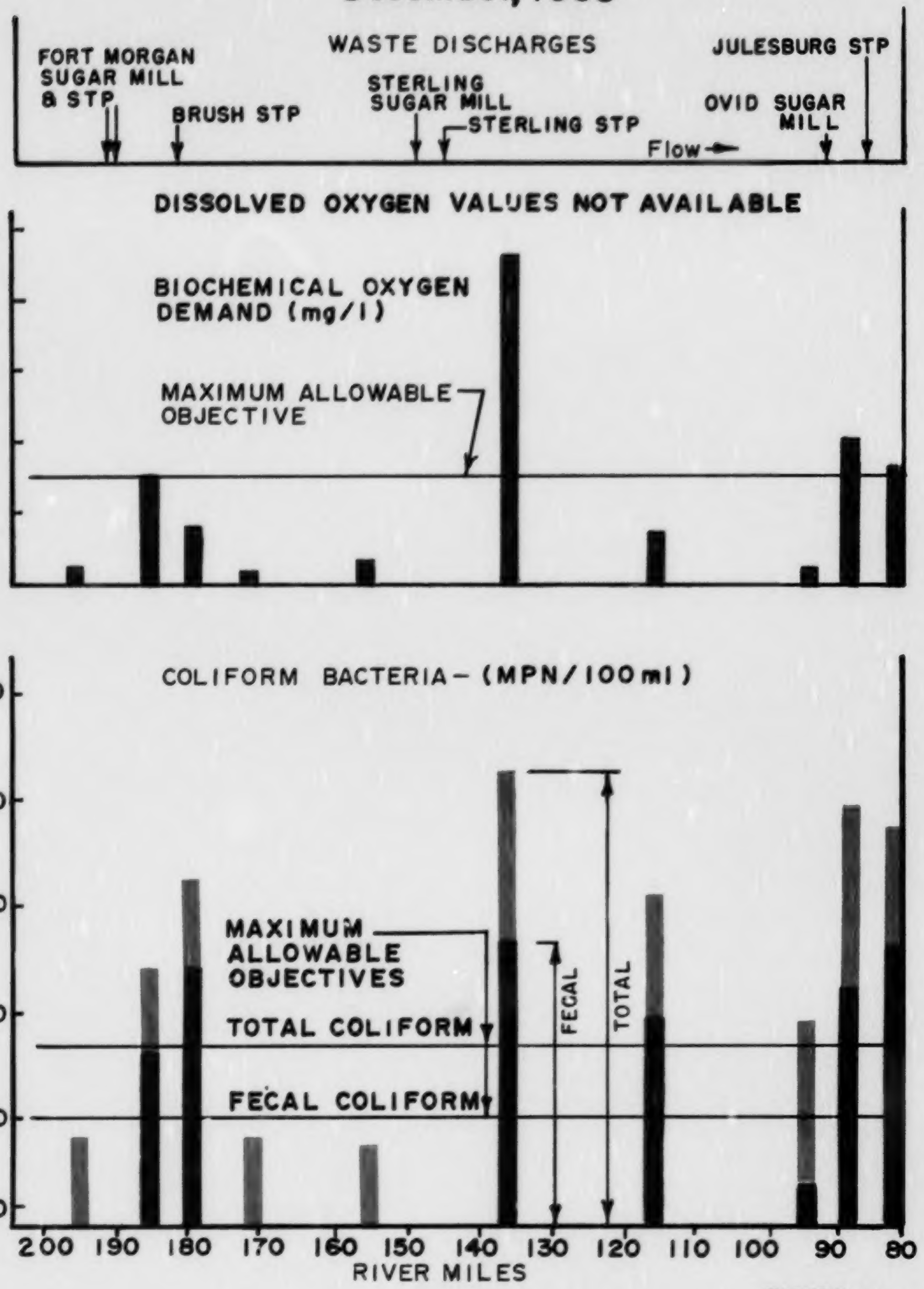


FIGURE 22

but again the problem of waste settling to the bottom of the stream and also canal diversions receiving part of the waste load, both serve to indicate greater waste reduction than is actually the case. The River waters 29 miles downstream of Sterling were still unacceptable in terms of stream quality objectives, but 50 miles downstream at a point above Ovid, the River waters were approaching background conditions. In December 1963 there was little waste load reaching Ovid from Sterling. However, at other times, the majority of the Sterling waste load is definitely carried downstream into the Ovid area, creating very poor water quality along this entire 50-mile stretch of River.

The Ovid sugar beet mill is located 11 miles upstream of the Colorado-Nebraska Stateline. It is the last waste source before the River leaves the State. In December 1963 the Ovid sugar factory was discharging 205,000 P.E. of waste load to the River and 8 miles farther downstream the Julesburg, Colorado municipal sewage treatment plant was adding about 800 P.E. of waste to the River. A large part of these organic wastes are carried forth to the Colorado-Nebraska Stateline.

The South Platte River was sampled at two locations below Ovid, at a point 3 miles above the Stateline, and at the Colorado-Nebraska Stateline. Waste loads from Ovid increased the 5-day BOD in the River from 2 to 20 mg/l, total coliform from 8,000 to 950,000 organisms/100 ml, and fecal coliform from 200 to 21,000 organisms/100 ml. At the Stateline there were slight decreases in BOD and total coliform, but the fecal coliform level continued to rise. The BOD at the Stateline was 5 mg/l in excess of the water quality objective. Total and fecal coliform bacteria were about 150 times and 35 times the maximum limits, respectively.

The December 1963 data do not reveal the worst water quality conditions that can exist in the lower South Platte River. Results from the Water Pollution Surveillance System Station located at Julesburg for the period of October 6 to December 30, 1964 showed an exceptionally high average BOD of 145 mg/l with an individual maximum value of 680 mg/l. During this same period, the average dissolved oxygen was 3.9 mg/l in the River and, further, there was complete absence of oxygen at certain times. Settling of wastes downstream of Ovid with formation of sludge deposits probably occured. The assimilative capacity of the lower South Platte River for wastes from Ovid and Sterling is insufficient to prevent severe pollution at the Stateline.

The last part of the presentation concerns biological findings and further bacteriological aspects of waste pollution. The biological findings consider algae, slime growths, stream bottom animals, and fishlife.

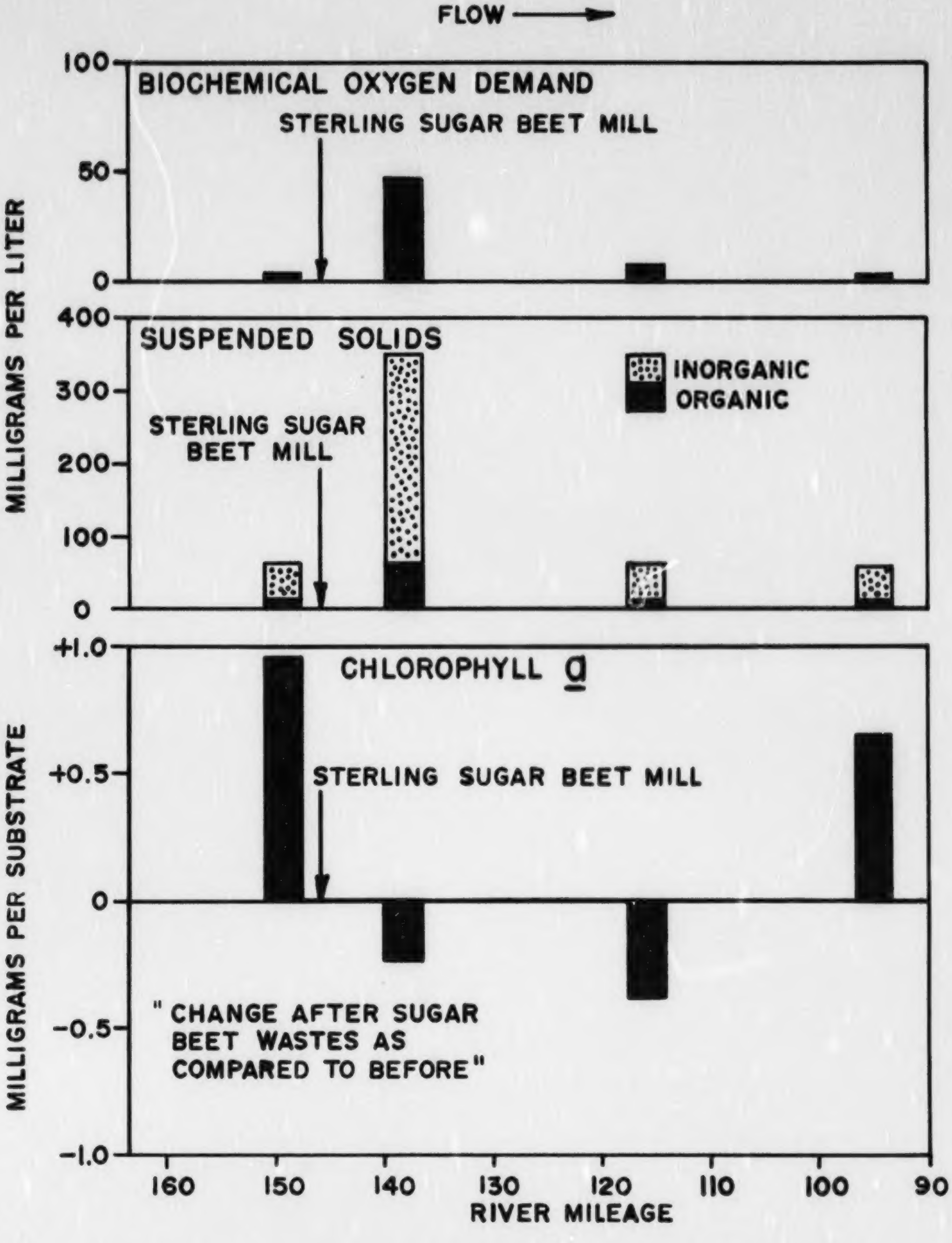
In polluted flowing water, bottom-attached algae are desirable as a primary source of food for aquatic animal life and also provide photosynthetic oxygen for a healthy stream. Effects of sugar beet wastes upon attached algae were determined by means of artificial substrates placed in the South Platte River and tributary streams. These specially constructed substrates support the growth of attached algae. Samples were collected in 1963 and 1964, prior to the sugar beet processing campaign, and again during the campaign. Attached algae were removed from the substrates and measurements were made of chlorophyll a content which is proportional both to the rate of algal growth and photosynthetic oxygen production. The analyses indicate that the presence of sugar beet wastes greatly reduced the growth of the attached algae within the streams affected.

The change in the algal community from summer to winter in the lower South Platte River between Sterling and Ovid is shown in Figure 23 and typifies stream conditions found below all sugar beet mill discharges in the Basin. The figure shows that the background station located above the city of Sterling and the Sterling sugar mill experienced a large increase in algal crop from summer to winter. Downstream of Sterling, however, the picture was completely reversed and there was an overall decrease of algae during the sugar beet processing season. The addition of sugar beet wastes significantly lowered the algal growth rate existing in the River for at least 27 miles downstream of Sterling. The South Platte River had recovered before reaching Ovid, which is shown by the increase in algal growth at the lowermost station.

The algal studies show that the large quantities of suspended solids contained in sugar beet processing wastes are the primary cause of reduced algae production. Figure 24 is an illustration of the solids contained in the Longmont sugar beet effluent which discharges to St. Vrain Creek. These solids reduce the penetration of light, thereby limiting the energy available for photosynthesis and also smothering the algal cells present in the stream. These wastes are exceptionally detrimental if they contain high BOD content in addition to suspended solids. The destruction of algae reduces photosynthetic oxygen available for biochemical decomposition which in turn extends the distance downstream before which stream recovery can occur.

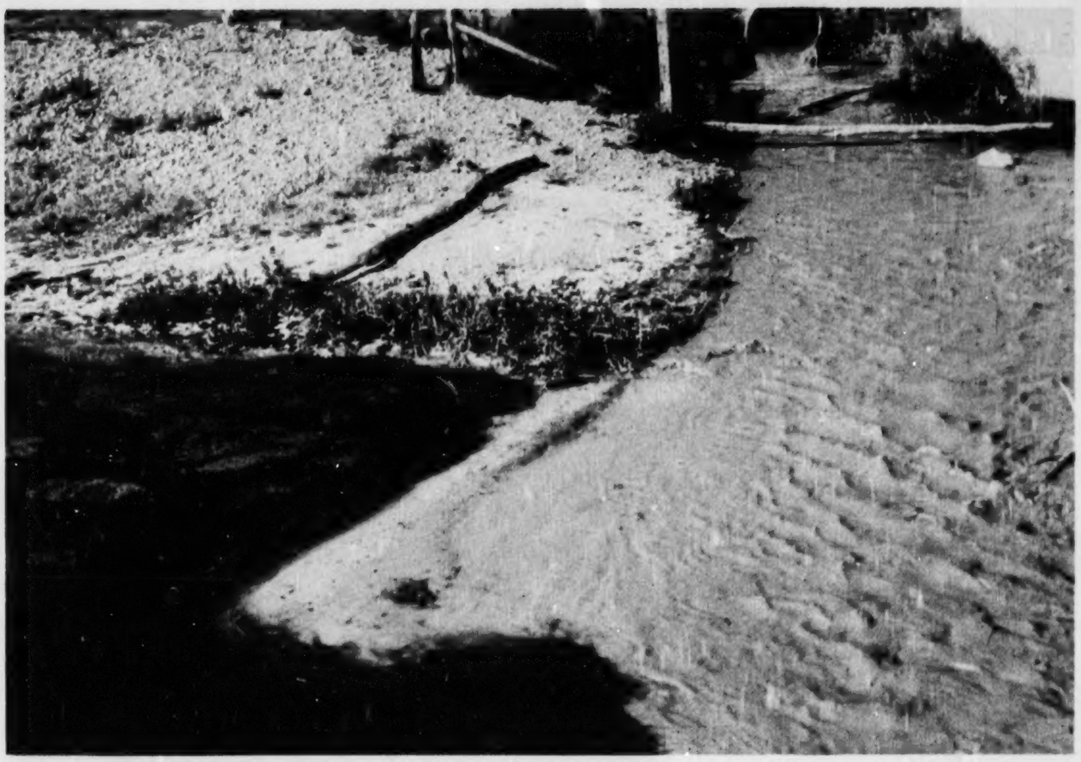
Slime growths were found below all sugar beet waste discharges. Suspended slime growths floating downstream and slime covered rocks and logs are aesthetically revolting to both sight and touch. Slime growths increase with BOD in the stream, but are reduced by extremely high levels of suspended solids. The Johnstown MSG sugar recovery plant discharged a waste that nurtured intense slime growths in the Little Thompson River continuously throughout the year. These growths were carried downstream into the lower Big Thompson River where they died and settled, forming dense black organic sludges covering the bottom of the River. Waste discharges from the Loveland sugar mill stimulated growth of slimes that covered the stream below this location as a thick blanket. White slime growths were found overlying the dense black organic sludges. Slime growths also inhibit the growth of attached algae and directly or indirectly destroy animal life in the stream. Figure 25 shows the slime growths accumulated on a crayfish collected from the South Platte River at Kersey. These growths caused by high levels of sugar beet wastes were in the process of over-growing the crayfish's gills, which in time would cause suffocation.

Stream bottom animals are a vital link in the aquatic food chain: plant tissue to bottom animal to fish. The stream bottoms underlying unpolluted watercourses are inhabited by bottom animals sensitive to pollutants, such as mayflies, caddisflies, and stoneflies. In the presence of pollution the sensitive forms are eliminated and the surviving tolerant species such as sludgeworms and bloodworms thrive. If the pollutant is an organic decomposable solid that can serve as food, the tolerant organisms can exist in great numbers. However, if conditions are severe even the tolerant forms may be reduced or even eliminated. Certain organisms from the above two groups comprise a third category called nuisance organisms which thrive with intermediate



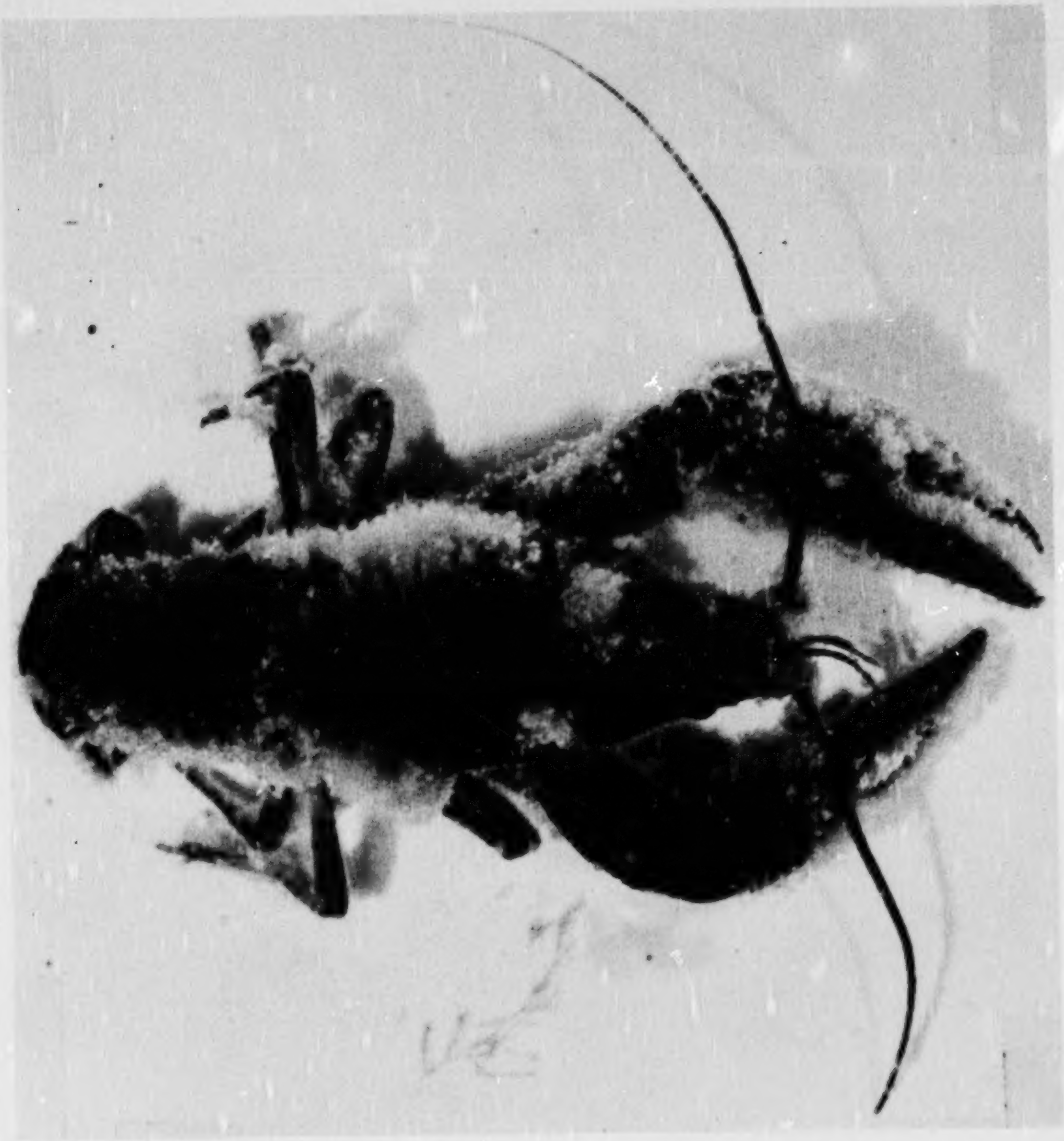
ALGAL CHANGES (CHLOROPHYLL a) AS AFFECTED BY BIOCHEMICAL OXYGEN DEMAND AND SUSPENDED SOLIDS, SOUTH PLATTE RIVER, STERLING TO OVID, COLORADO, AUGUST AND OCTOBER, 1963.

FIGURE 23



PHOTOGRAPH OF WASTE EFFLUENT FROM THE LONGMONT SUGAR BEET MILL ILLUSTRATING LARGE QUANTITIES OF SUSPENDED SOLIDS DISCHARGED OCTOBER, 1964

FIGURE 24



PHOTOGRAPH OF CRAYFISH OVERGROWN WITH SLIMES.
SOUTH PLATTE RIVER, KERSEY, COLORADO
OCTOBER, 1964.

FIGURE 25

or moderate amounts of pollution. Bottom animal samplings were taken prior to the onset of the sugar beet processing campaign in August, and again in October under the influence of campaign wastes. The picture obtained on the lower South Platte River in 1963 more or less typifies conditions in the other streams below the sugar beet mills. Bottom animal results from Sterling to Ovid are illustrated in Figure 26.

During the sugar beet processing campaign, as shown by the solid lines in Figure 26, there was general elimination of the sensitive bottom animals and also the tolerant sludgeworms directly below the sugar mill. This was primarily caused by the excessive quantities of organic solids discharged into the streams. In St. Vrain Creek a net with one square-foot opening was exposed to the current for one minute; Figure 27 shows the very large amounts of sugar beet particles and chunks that were floating in St. Vrain Creek below the Longmont sugar mill. In addition, beet chunks were found covering the stream bottom and rolling along as part of the bed load.

Since even the tolerant sludgeworms were affected, pollution was severe enough to inhibit the digestion of organic sludges found in the streams; these worms normally consume several times their weight in organic material each day, thereby reducing the BOD of these sludges. After considerable distance downriver, there was sufficient stream recovery to permit the survival of bottom animals in gradually increasing numbers.

The bottom animal communities in the summertime as shown by the dashed lines in Figure 26 were found to be sustained and nourished by a good supplement in the stream. This food supplement consisted of sludge deposits formed below all sugar beet mills from waste discharges of the previous campaign. This residual pollution caused large increases in the bottom animal communities many months after the beet mill waste discharges had ceased.

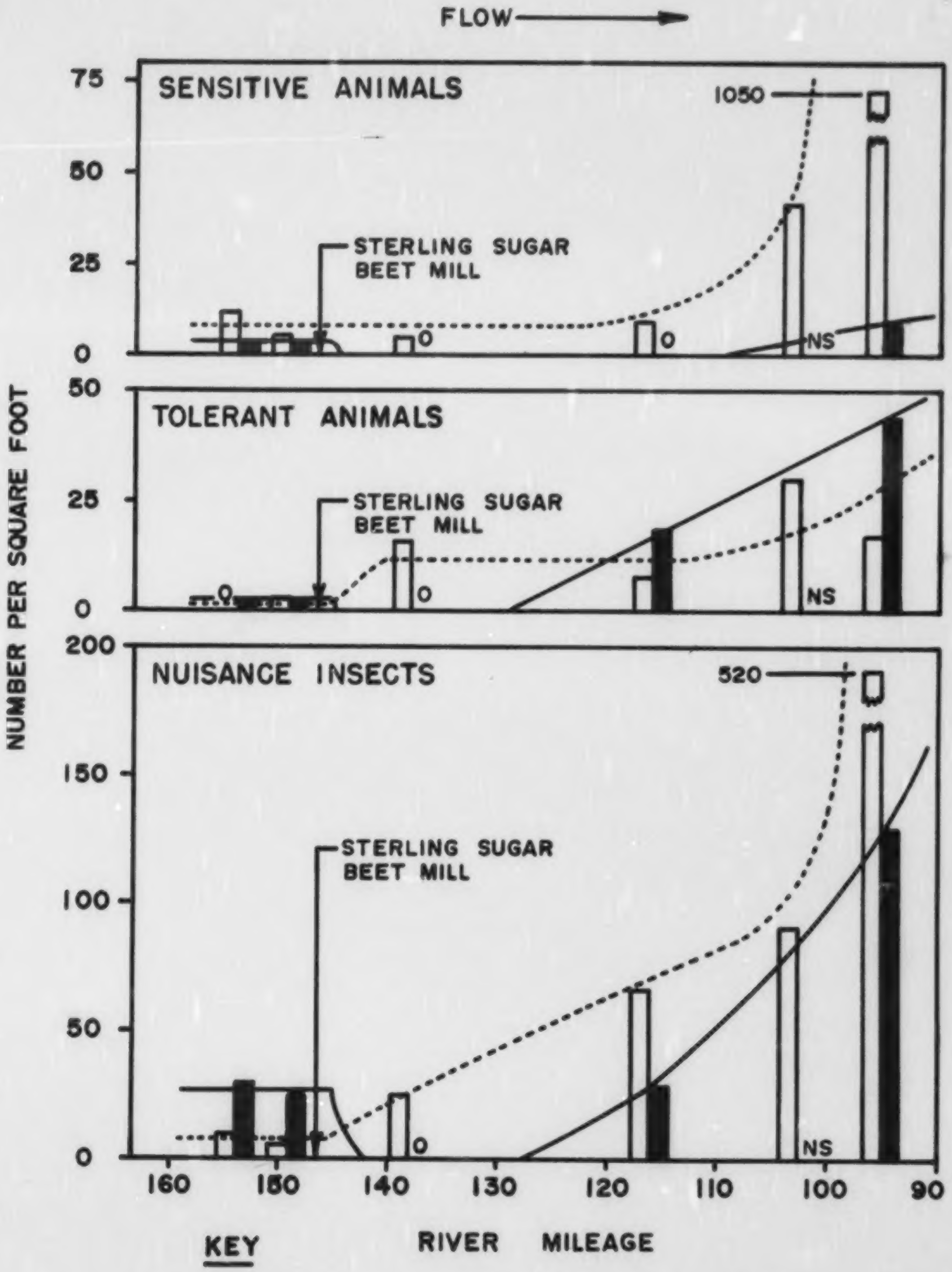
A large increase in noxious insects in both winter and summer was noted downstream of each sugar beet mill feeding on the beet solids and other organic matter present. Besides causing nuisance, these organisms are related to a greater incidence of disease transmission.

The sugar beet wastes trapped in pools, off-channel areas, and irrigation canals, and the organic material available in the form of stream bottom sludge deposits greatly promote mosquito and other insect production. Odor conditions are also amplified.

Insect vector control is very important in the South Platte River Basin and every effort should be made, including waste abatement, to mitigate existing vector problems.

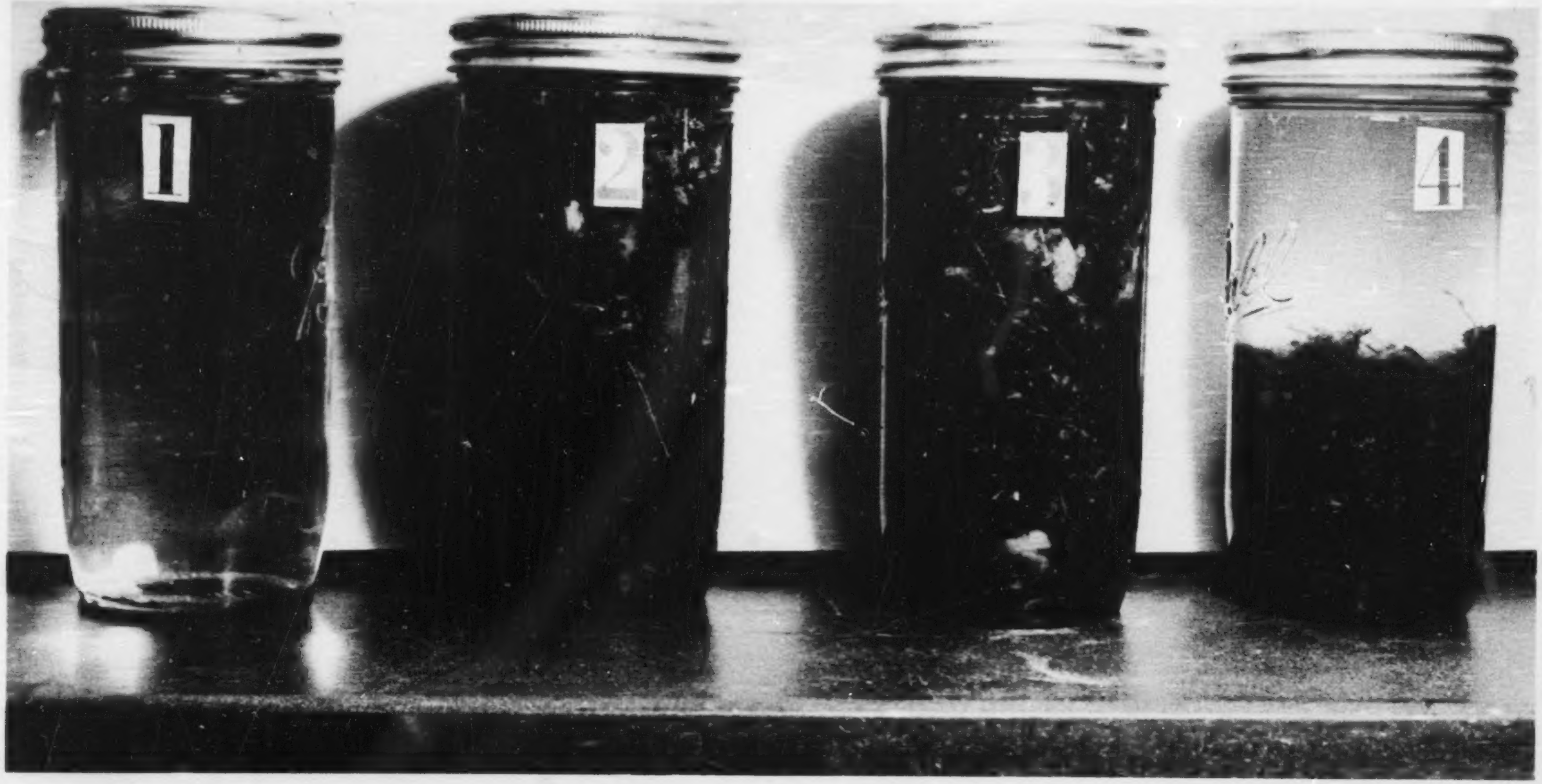
Limited study was made of the fishery resources existing at the present time in the South Platte River Basin. At various times during 1963 and 1964 fish were observed at many of the sampling stations, but the very large majority were carp, suckers, and many top minnows. Game fish, such as bass and sunfishes were rarely seen. Under present conditions, the annual decimation of habitat by sugar beet wastes definitely limits the fish population and species found. With good water quality, the development of a good fishery resource in these streams would provide back-yard recreation in the most densely-populated River Basin in Colorado where this resource is in heavy demand.

The large numbers of total coliform, fecal coliform, and fecal streptococci bacteria in sugar beet wastes discharged to receiving streams



BOTTOM ANIMALS, DIRECT SAMPLING, SOUTH PLATTE RIVER, STERLING TO OVID, 1963.

FIGURE 26



SUSPENDED CHUNKS OF SUGAR BEETS, ST. VRAIN CREEK, OCTOBER, 1964: (1) ABOVE LONGMONT, COLORADO; (2) U.S. HIGHWAY 87 BELOW LONGMONT; (3) 1 MILE ABOVE CONFLUENCE WITH SOUTH PLATTE RIVER; (4) SOUTH PLATTE RIVER, HIGHWAY 60 (MATERIAL RETAINED IN A NET WITH A SQUARE-FOOT OPENING EXPOSED TO THE CURRENT FOR ONE MINUTE).

FIGURE 27

has for some time been a matter of serious concern. Extensive bacterial studies were undertaken on the North Platte River in Wyoming and Nebraska in 1960, 1961, and 1962 below the five sugar beet mills from Torrington, Wyoming, extending downstream beyond Bayard, Nebraska. Special laboratory investigations have been carried out by the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, from late 1963 to the present. Laboratory and field studies of the South Platte River Basin Project have considered the bacterial aspects of sugar beet pollution since late 1963. Additional study was undertaken in October 1963 by the U. S. Public Health Service, of four sugar beet mills in Minnesota and North Dakota on the Red River of the North. The following discussion on bacteria is based upon the above studies.

Coliform bacteria universally occur in sanitary sewage. With a few exceptions, these bacteria are not harmful and have been used by regulatory agencies for many decades as an indicator of the probable presence of pathogenic organisms. Objections have been made to the use of total coliform densities in that their origin is not exclusively from fecal sources. While this is true, the Eschericia species comprising part of the total coliform group is derived exclusively from human or animal excreta and its presence is evidence of fecal contamination. A second indicator group, the fecal coliform bacteria, is almost exclusively derived from the guts of warm-blooded animals. Recently the fecal streptococci group has been accepted and used as a third indicator of warm-blooded animal pollution. This group is not known to multiply in surface waters and rarely occurs on surface soil or vegetation not contaminated by sewage. Bacterial studies of sugar beet wastes in the South Platte River Basin have relied upon use of the indicator groups, total coliform, fecal coliform, and fecal streptococci.

Salmonella is a genus of bacteria pathogenic to man and to warm-blooded animals. These pathogens are discharged from the intestines of infected man and animals. Because of disease-producing capabilities, their presence in receiving water constitutes a health hazard through indirect or direct contact with these waters. Salmonella was not previously detectable in waste water but recent techniques now make possible the isolation of these pathogens even at extremely low concentrations. Salmonella isolation was first used in the Red River of the North studies in October, 1965.

The relationship between fecal coliform and fecal streptococci bacteria provides further indication of the origin of fecal pollution. Ratios of fecal coliform to fecal streptococci that are greater than 2:1 generally indicate that pollution was primarily derived from domestic sewage. Ratios less than 1:1, indicate that the majority of pollution originated from the wastes of warm-blooded animals other than man, such as stockyard and dairy animals.

The bacterial densities found in the final waste discharges from the ten sugar factories in the South Platte River Basin are shown in the following table. Although the total coliform densities in the effluents are quite important, particular emphasis is placed upon the fecal coliform and fecal streptococci densities. These levels were high to very high with the exception of the Loveland mill discharge and waste outfalls A and B at the Johnstown plant. The low coliform densities at

BACTERIAL DENSITIES IN SUGAR BEET PLANT WASTES

South Platte River Basin

	Date	Total Coliform (MPN/100ml)	Fecal Coliform (MPN/100ml)	Fecal Strep (No./100ml)
Brighton	1-65	19,500,000	4,100,000	11,000,000
Longmont	11-65	490,000	22,000	6,350,000
Loveland	1-64	2,700	590	---
Windsor	1-64	6,620,000	52,100	---
Eaton	11-65	33,000,000	640,000	57,500,000
Greeley	1-64	3,060,000	103,000	---
Fort Morgan	12-63	1,600,000	13,000	---
Sterling	12-63	17,100,000	251,000	---
Ovid	12-63	18,700,000	362,000	---
Johnstown	11-65			
Outfall A-- Clean water sewer		13,000	4,900	160,000
Outfall B-- Lagoon effluent		49,000,000	950,000	3,600

Loveland were caused by high pH values in the waste effluent of 10.1 to 10.5, which resulted in significant bacterial die-off. The Johnstown plant is quite unlike the other nine sugar mills in that it receives intermediate raw sugar from other factories and produces MSG in addition to refined sugar. The bacterial picture at Johnstown is different because of the nature of operations. Outfall A showed high fecal strep but low fecal coliform densities; whereas, the reverse was true for Outfall B.

The ratio of fecal coliform to fecal streptococci contained in waste discharges from the Brighton, Longmont, and Eaton mills were respectively 0.37, 0.003, and 0.01. These ratios together with high fecal streptococci levels definitely indicate that bacterial pollution was primarily derived from the fecal extreta of animals rather than from humans. In November 1965 the Project carried out further tests to identify the specific groups of fecal streptococci present in sugar beet wastes. Data were collected from the Eaton sugar mill and also from the town of Eaton sewage treatment plant. The sewage treatment plant effluent gave perspective on the fecal strep groups expected in domestic or human wastes. The treated domestic sewage showed 38 percent of the streptococci were of the enterococcus group which are of human origin, 22 percent were of the strep equinis or strep salivarius group, which are of human or animal origin, 26 percent were the strep bovis species associated with animal origin, and 14 percent were undefined. On the other hand, the sugar beet waste contained entirely strep bovis. The strep bovis species are strongly associated with cattle and other domestic animal feces. Other investigators have shown that the excreta from cows contains 63 percent or more strep bovis together with other streptococci species. From these investigations it is concluded that animal manure, which is used to fertilize sugar beets, transmits large numbers of fecal microorganisms which are subsequently carried by the sugar beets into the processing plant. These organisms appear in the waste processing effluents and then in the Basin streams.

Direct sampling and recovery of pathogenic organisms in sugar beet wastes has been attempted only in the Red River of the North study. Of three sugar beet mills studied in that area, Salmonella was found in the wastes from two of the plants--in one case before the wastes entered the treatment pond and within the treatment pond in the second case. In addition, Salmonella was found in the river below these sugar beet mills and municipal discharges.

The Red River of the North study also considered the survival rates of fecal coliform, fecal strep, and Salmonella within the waste treatment ponds utilized by the sugar mills. Known quantities of bacteria were innoculated into samples collected of pond influent and effluent. These samples were then incubated in the laboratory at temperatures corresponding to field conditions, and bacterial counts were made on the samples at prescribed intervals. The studies showed that Salmonella is an extremely persistent organism particularly at the lower temperatures encountered in the wintertime. It was indicated that nutrients contained in the wastes promoted the growth and multiplication of Salmonella. To reduce the health hazard associated with these organisms, the nutrients would need to be reduced or eliminated.

Continuing studies at the Robert A. Taft Sanitary Engineering Center have provided additional information on the bacterial problems associated with sugar beet wastes. Fecal coliforms have been found on field beets, in irrigation water, on dirt removed from the beets arriving at the plant, and on the dirt and trash adhering to the beets stockpiled at the plant site. Beets stored at the plant site and in outlying areas such as railroad sidings may be subject to heavy rodent activity causing significant increase in fecal contamination. In the plant there may be growth of bacterial populations due to recycling of waste water, and standing water.

Sugar beets are known to be a complex mixture of various carbohydrates including pectin, pentosans, cellulose, purines, and related compounds such as, betaines and urea, and vitamins. It is the conversion of these many organic components into waste which cause the large problems in sugar beet waste disposal and treatment. These nutrients retard the normal die-away of bacteria organisms in the receiving stream. Thus the longer survival time and possible regrowth of bacteria, including enteric pathogenic organisms, negates in part the natural capabilities of the stream in assimilating bacterial loads. Also, this extends the distance downstream for recovery to non-hazardous levels. From the available information, there is no reason to believe that enteric pathogens in general are less persistent and have shorter survival times than indicator organisms. It is concluded that a health hazard is involved in recreational uses of waters polluted by the bacteria in beet sugar wastes.

Nutrient levels may be significantly reduced by extended storage of sugar beet wastes. Following nutrient removal, disinfection will effectively reduce the residual organisms, and will prevent aftergrowth of undesirable bacteria in the receiving stream. Proper disinfection of all sugar beet waste effluents is included in the recommendations for pollution abatement.

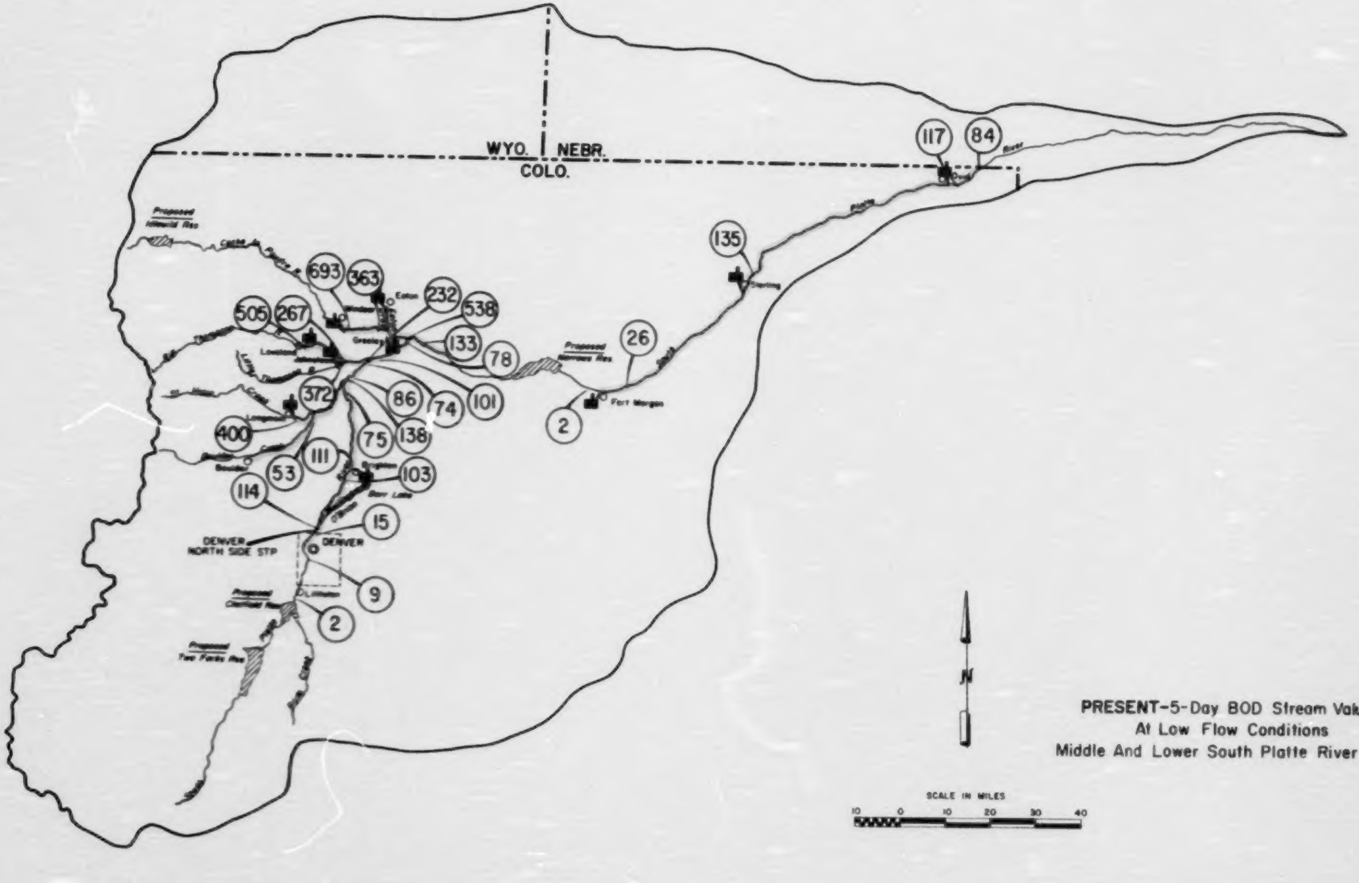
In order to provide adequate water quality in the middle and lower portions of the South Platte River and its tributaries, for all legitimate uses, both present and future, a plan of waste abatement was formulated. Development of the plan consisted of three parts undertaken concurrently:

(1) establishing maximum allowable future waste loads that will guarantee stream water quality in conformance with the allowable objectives;

(2) evaluating technological and economic factors, and establishing a degree of waste treatment that is feasible for each waste source; and

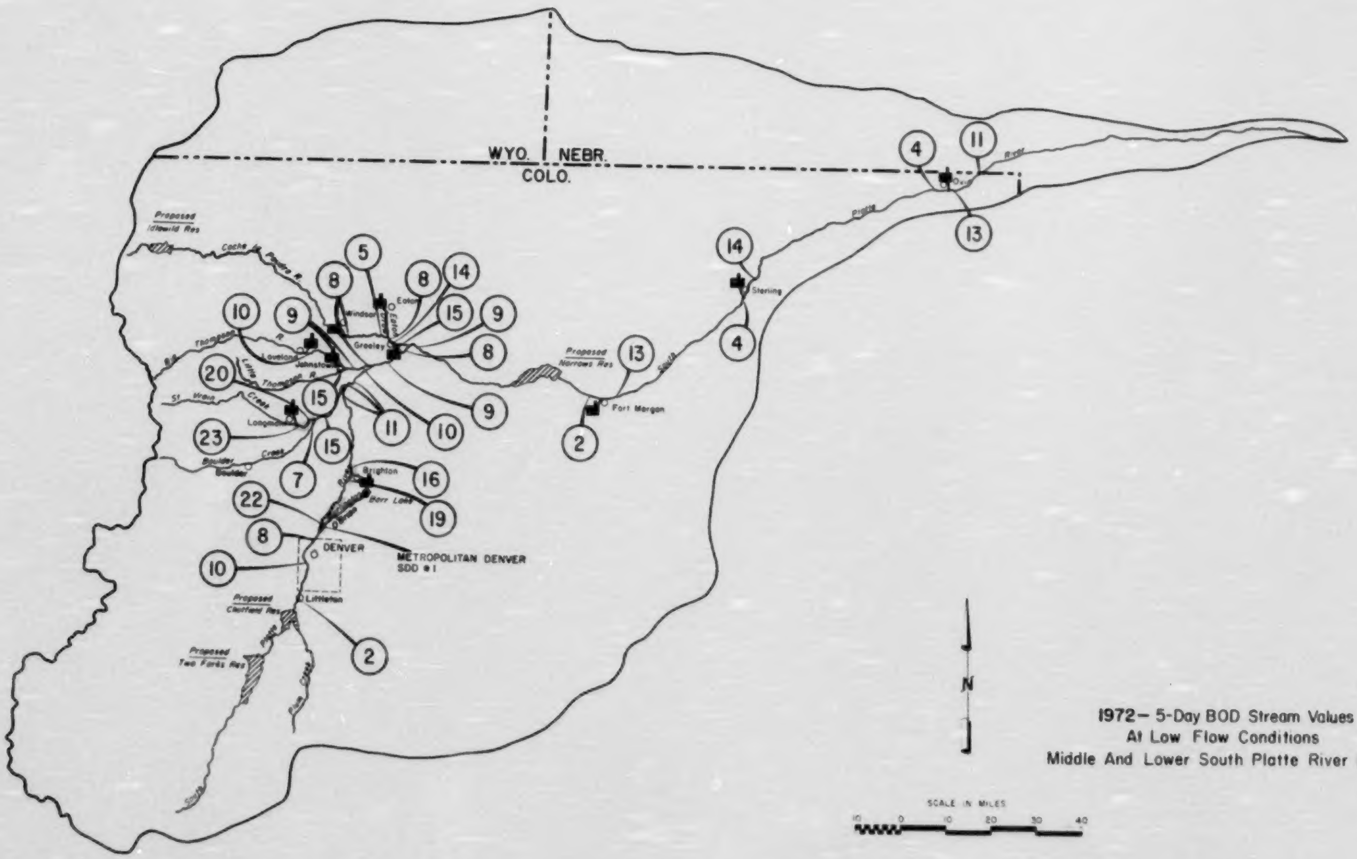
(3) determining flow augmentation necessary for water quality control when the most efficient waste treatment, by itself, cannot satisfy the water quality objectives.

First, a picture was constructed of the most severe pollution that could be expected under present-day conditions. Then, with the pollution abatement plan in effective operation, situations were developed for the years 1972 and 2000 which approximate the most severe pollution that may be expected in the future. These conditions for the present, for the year 1972, and for the year 2000, in terms of 5-day BOD levels in the streams, are shown, respectively, in Figures 28, 29, and 30. The pollution abatement plan as shown for the year 1972 and 2000 is designed to meet water quality objectives at all times except during the most severe periods. Limited stretches of stream may exceed, to some degree, the allowable levels but these events should be of minor consequence. The predictions, of course, are subject to the uncertainties involved in any projection of population and industrial growths. The pollution abatement schedule necessary to meet the above objectives is given in the Recommendations Section of this report.


WYO.
NEBR.
COLO.
Proposed
Cache la Poudre R.
693
363
Eaton
232
538
505
267
Loveland
Greeley
133
78
Proposed
26
Fort Morgan
2
135
Sterling
117
84
Platte
River
372
400
Boulder
86
74
101
75
138
111
53
103
114
Bar Lake
15
DENVER
NORTH SIDE STP
DENVER
9
Proposed
Littleton
2
Proposed
Two Forks Res
N
SCALE IN MILES
10
0
10
20
30
40

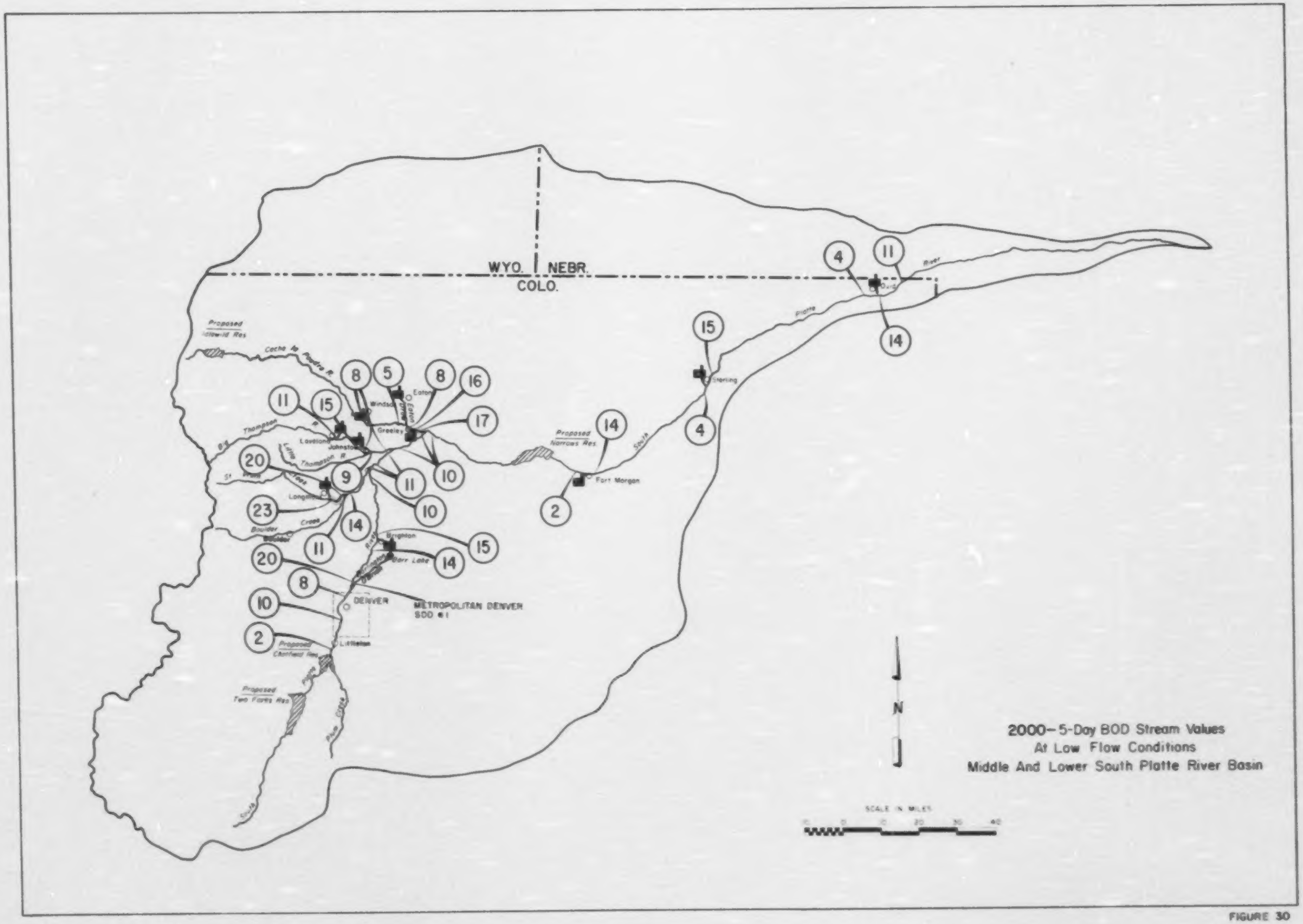
PRESENT-5-Day BOD Stream Values
At Low Flow Conditions
Middle And Lower South Platte River Basin

FIGURE 28


WYO.
NEBR.
COLO.
Proposed Idlewild Res
Cache la Poudre R.
Big Thompson R.
Little Thompson R.
St. Vrain Creek
Boulder Creek
Boulder
Loveland
Johnstown
Windsor
Eaton
Greeley
Longmont
Brighton
Barr Lake
DENVER
METROPOLITAN DENVER SDD #1
Littleton
Proposed Chatfield Res
Proposed Two Forks Res
Plum Creek
Proposed Narrows Res
Fort Morgan
South Platte
Sterling
Platte River
Julesburg
5
8
8
14
10
9
15
9
8
20
15
9
23
11
10
15
7
16
22
19
8
10
2
13
2
14
4
4
11
13
N
SCALE IN MILES
10
0
10
20
30
40

1972– 5-Day BOD Stream Values
At Low Flow Conditions
Middle And Lower South Platte River Basin

FIGURE 29


WYO.
NEBR.
COLO.
Proposed Idlewild Res
Cache la Poudre R.
Big Thompson R
Little Thompson R
St Vrain Creek
Boulder Creek
Boulder
Loveland
Johnstown
Windsor
Eaton
Eaton Draw
Greeley
Longmont
Brighton
Barr Lake
Proposed Narrows Res.
Fort Morgan
South Platte River
Sterling
Julesburg
DENVER
METROPOLITAN DENVER SDD #1
Littleton
Proposed Chatfield Res
Proposed Two Forks Res
Plum Creek
South Platte
8
5
8
16
11
15
17
20
9
11
10
23
14
10
11
15
20
14
8
10
2
14
2
15
4
4
11
14
N
SCALE IN MILES
0
10
20
30
40

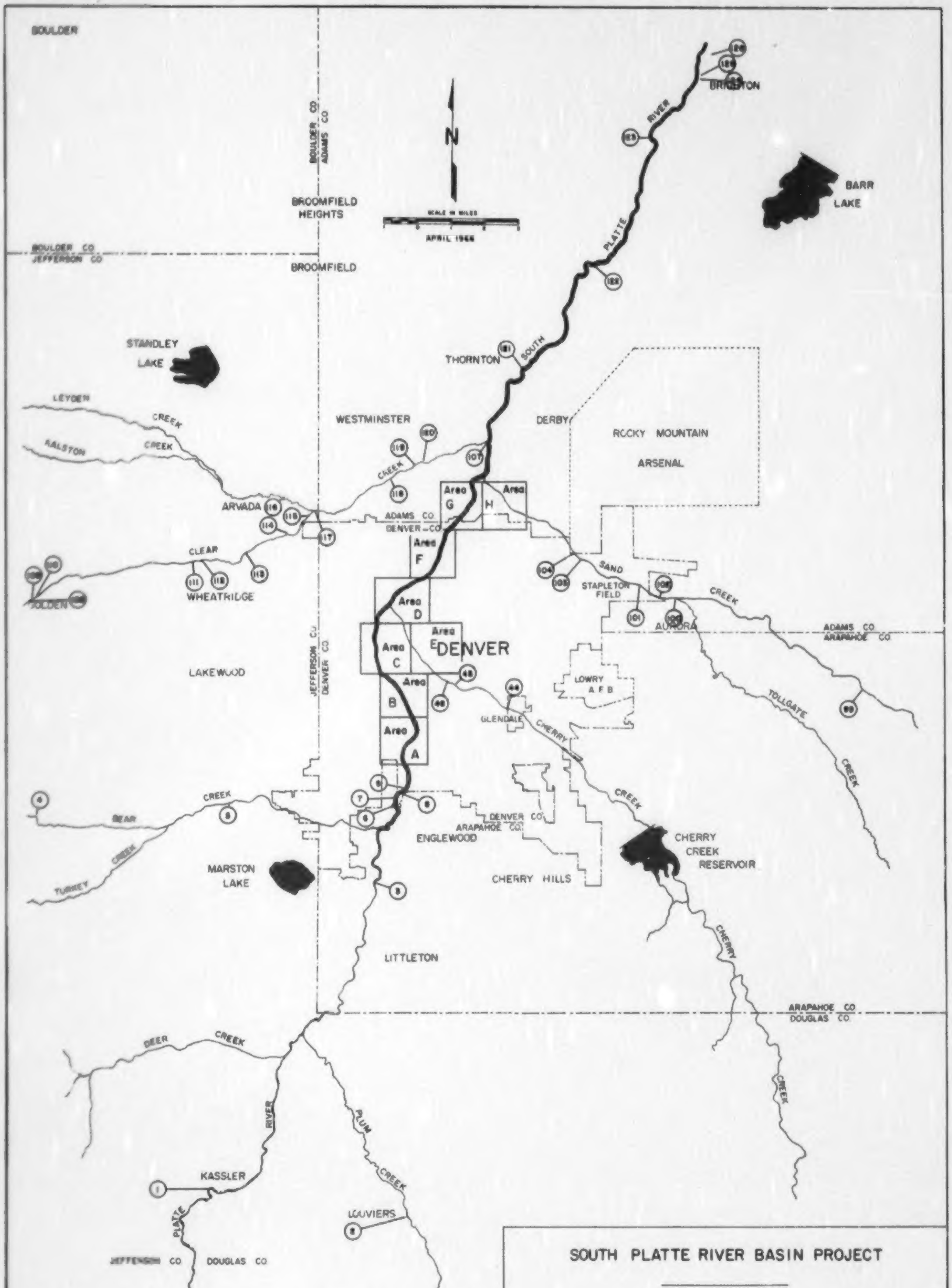
2000-5-Day BOD Stream Values
At Low Flow Conditions
Middle And Lower South Platte River Basin

FIGURE 30

APPENDICES

APPENDIX A

Project Sampling Data
Denver Metropolitan Area


BOULDER
BOULDER CO
ADAMS CO
N
SCALE IN MILES
APRIL 1966
BROOMFIELD HEIGHTS
BOULDER CO
JEFFERSON CO
BROOMFIELD
BRIGHTON
SOUTH
PLATTE
RIVER
123
122
121
BARR LAKE
STANDLEY LAKE
THORNTON
LEYDEN
CREEK
RALSTON
CREEK
WESTMINSTER
DERBY
ROCKY MOUNTAIN ARSENAL
120
119
CREEK
107
118
Area G
Area H
ARVADA
116
115
114
117
ADAMS CO
DENVER CO
Area F
CLEAR
111
112
113
110
109
108
GOLDEN
WHEATRIDGE
104
103
SAND
STAPLETON FIELD
105
101
100
CREEK
AURORA
ADAMS CO
ARAPAHOE CO
Area D
Area E
Area C
DENVER
LAKEWOOD
JEFFERSON CO
DENVER CO
48
46
44
LOWRY A F B
GLENDALE
CHERRY
Area B
Area A
TOLLGATE
98
CREEK
4
CREEK
BEAR
5
7
6
8
DENVER CO
ARAPAHOE CO
ENGLEWOOD
CREEK
TURKEY
CREEK
MARSTON LAKE
3
CHERRY HILLS
CHERRY CREEK RESERVOIR
CHERRY
LITTLETON
ARAPAHOE CO
DOUGLAS CO
DEER
CREEK
RIVER
CREEK
PLUM
CREEK
KASSLER
1
PLATTE
LOUVIERS
2
JEFFERSON CO
DOUGLAS CO
NORTH
FORK
SOUTH

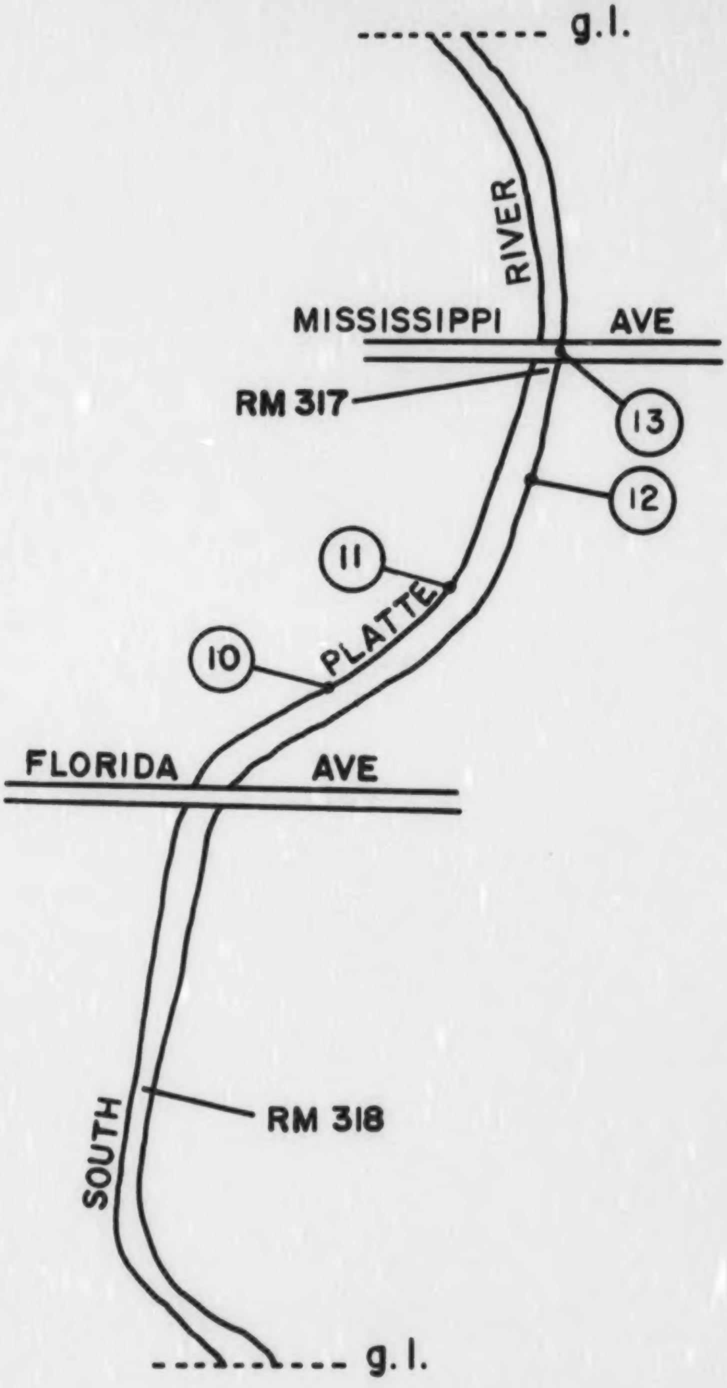
SOUTH PLATTE RIVER BASIN PROJECT

LOCATION OF WASTE DISCHARGES METROPOLITAN DENVER AREA

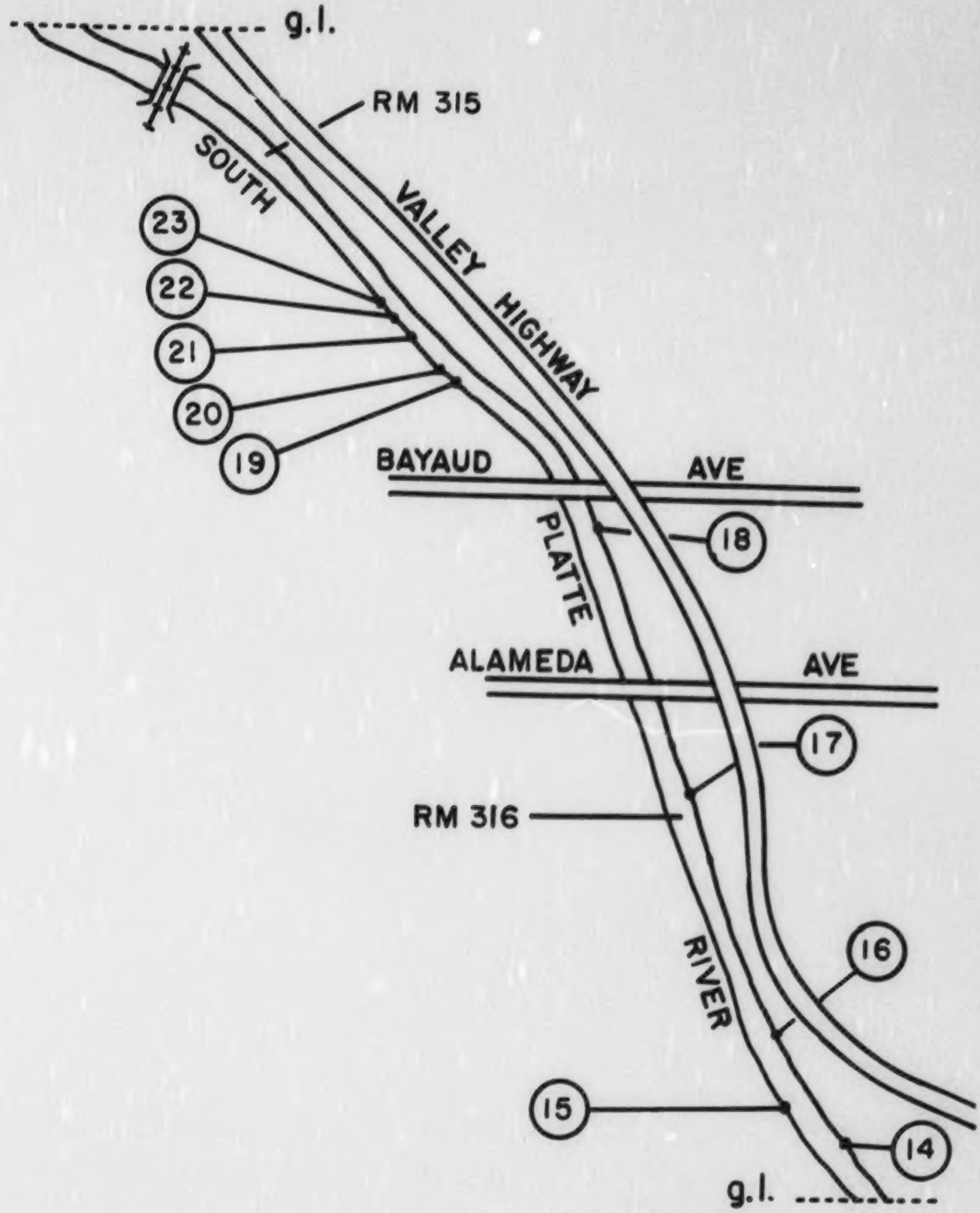
DEPT. OF HEALTH, EDUCATION, & WELFARE
WATER POLLUTION CONTROL ADMINISTRATION

REGION VIII
DENVER, COLO.

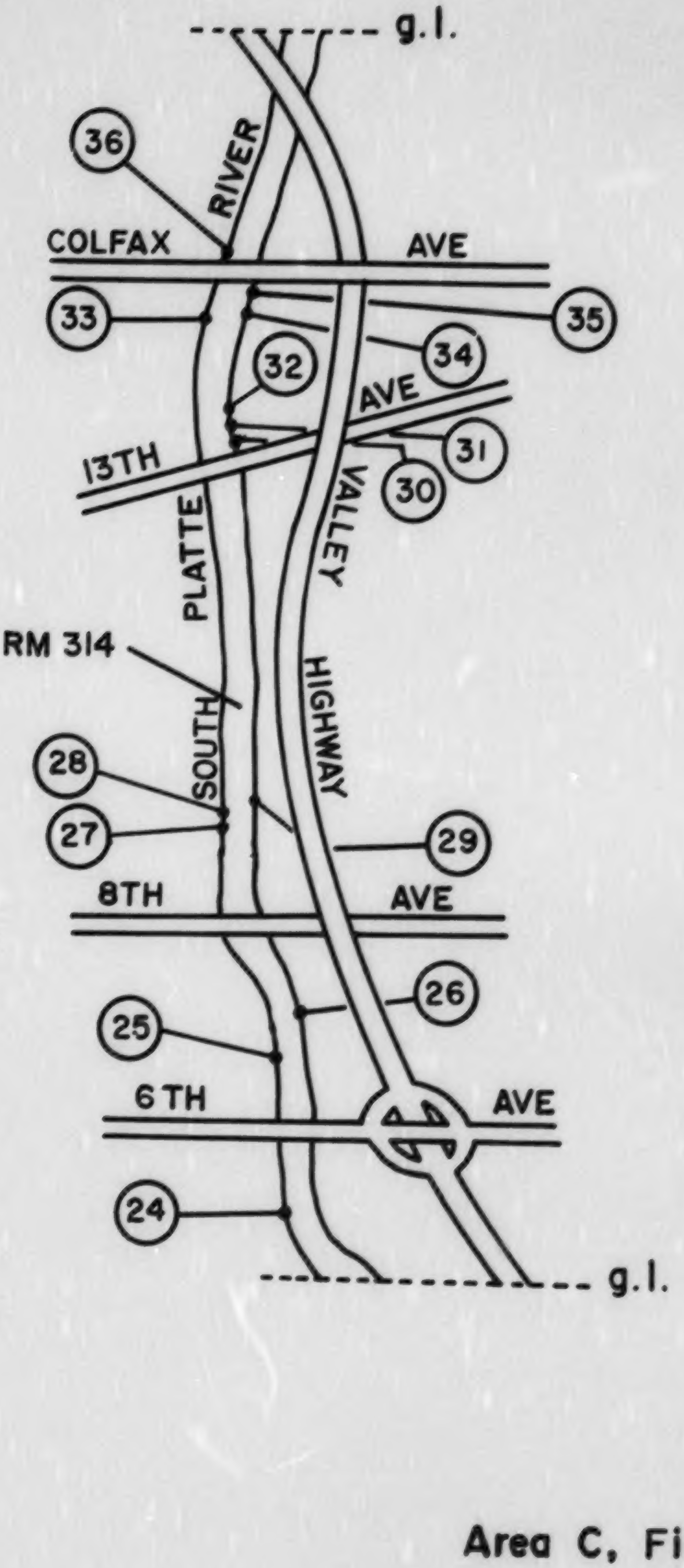
APPENDIX A-FIGURE 1


g.l.
RIVER
MISSISSIPPI AVE
RM 317
13
12
11
PLATTE
10
FLORIDA AVE
SOUTH
RM 318
g.l.

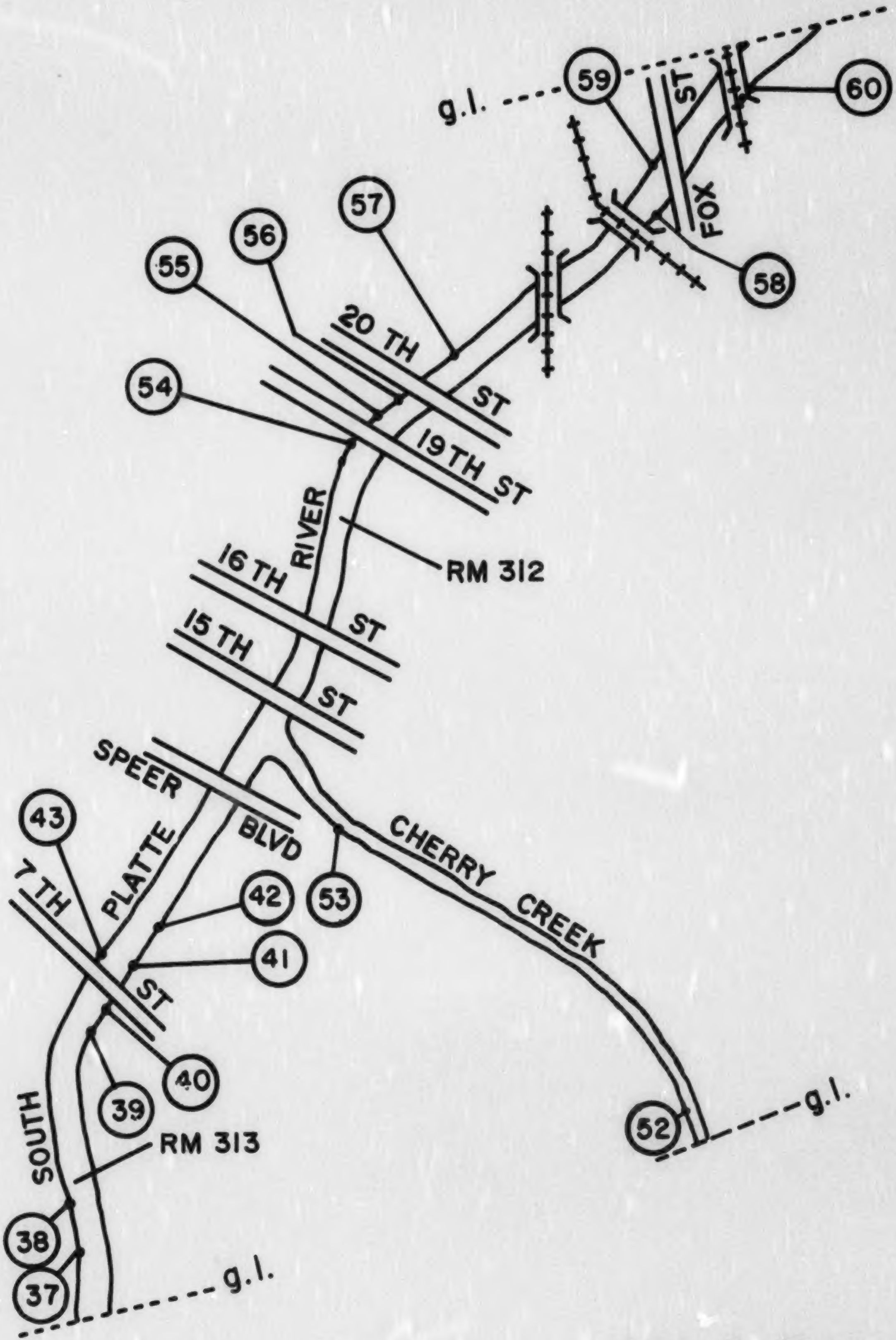
Area A, Figure 1


g.l.
RM 315
SOUTH
VALLEY
HIGHWAY
23
22
21
20
19
BAYAUD
AVE
PLATTE
18
ALAMEDA
AVE
17
RM 316
RIVER
16
15
14
g.l.

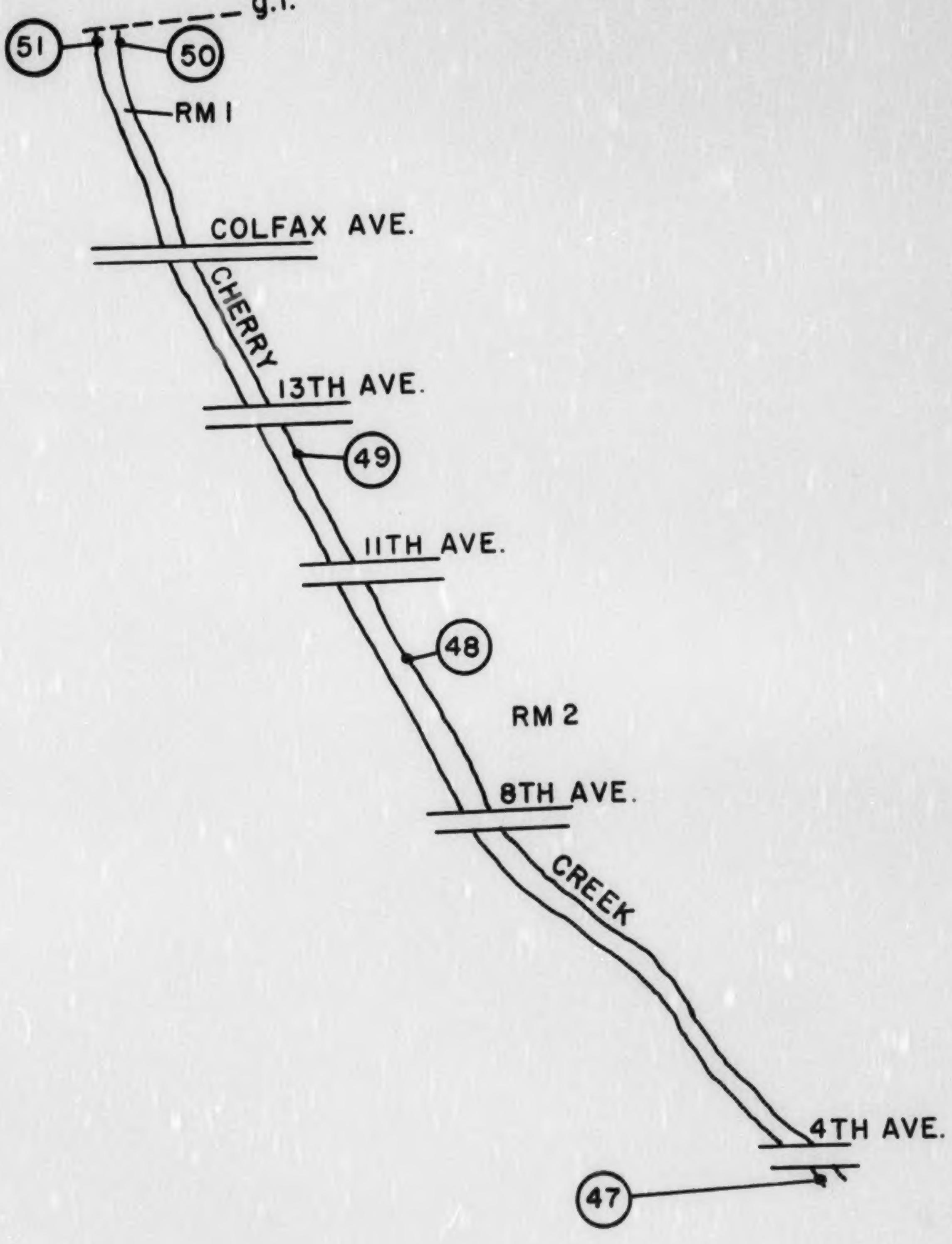
Area B, Figure 1


g.l.
36
RIVER
COLFAX
AVE
33
35
34
32
AVE
13TH
31
VALLEY
30
PLATTE
RM 314
HIGHWAY
SOUTH
28
27
29
8TH
AVE
26
25
6 TH
AVE
24
g.l.

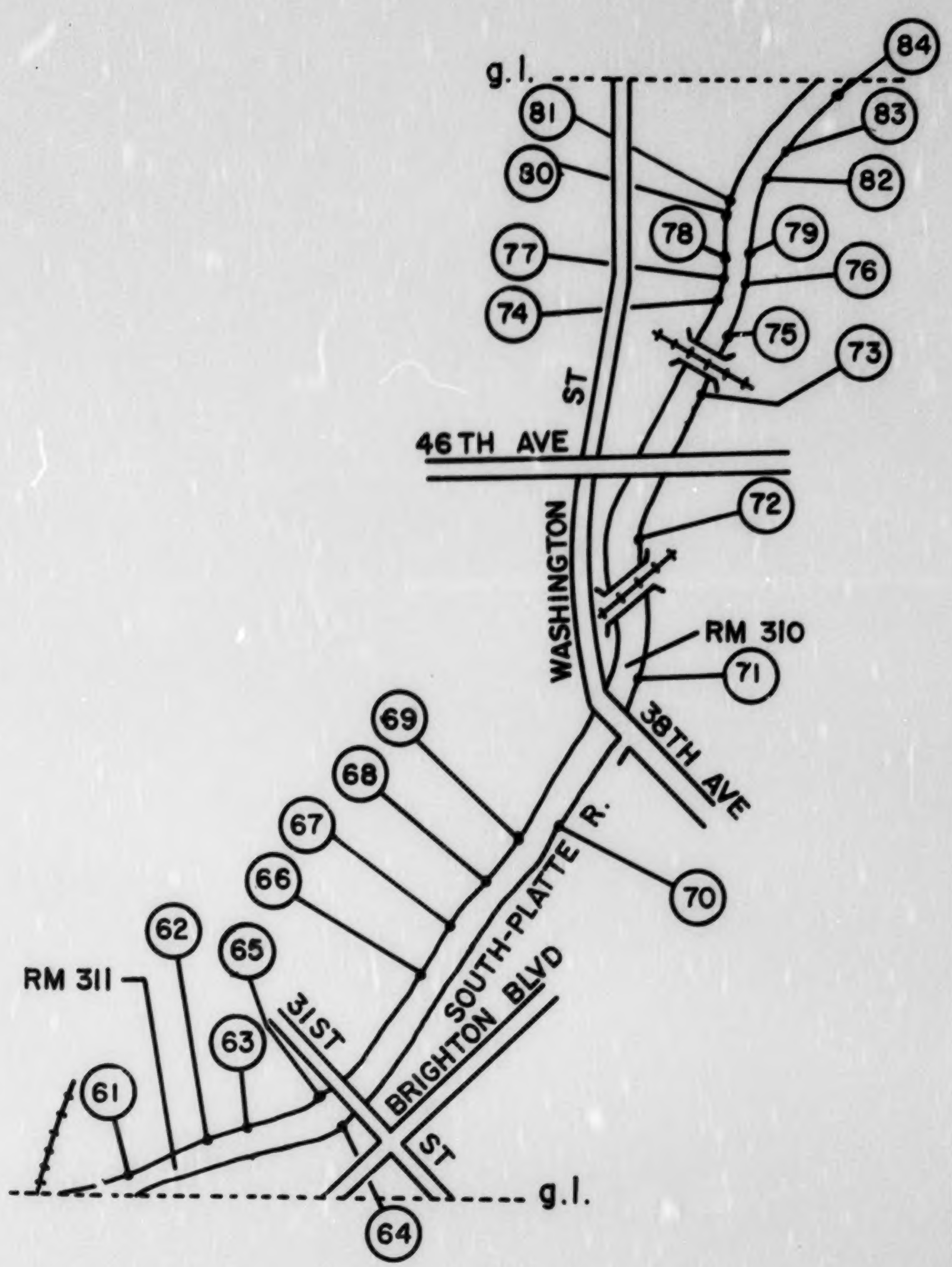
Area C, Figure I


g.l.
59
60
ST
FOX
57
56
55
58
20 TH
ST
54
19 TH ST
RIVER
RM 312
16 TH
ST
15 TH
ST
SPEER
BLVD
CHERRY
CREEK
43
PLATTE
42
53
7 TH
41
ST
40
39
SOUTH
RM 313
52
g.l.
38
37
g.l.

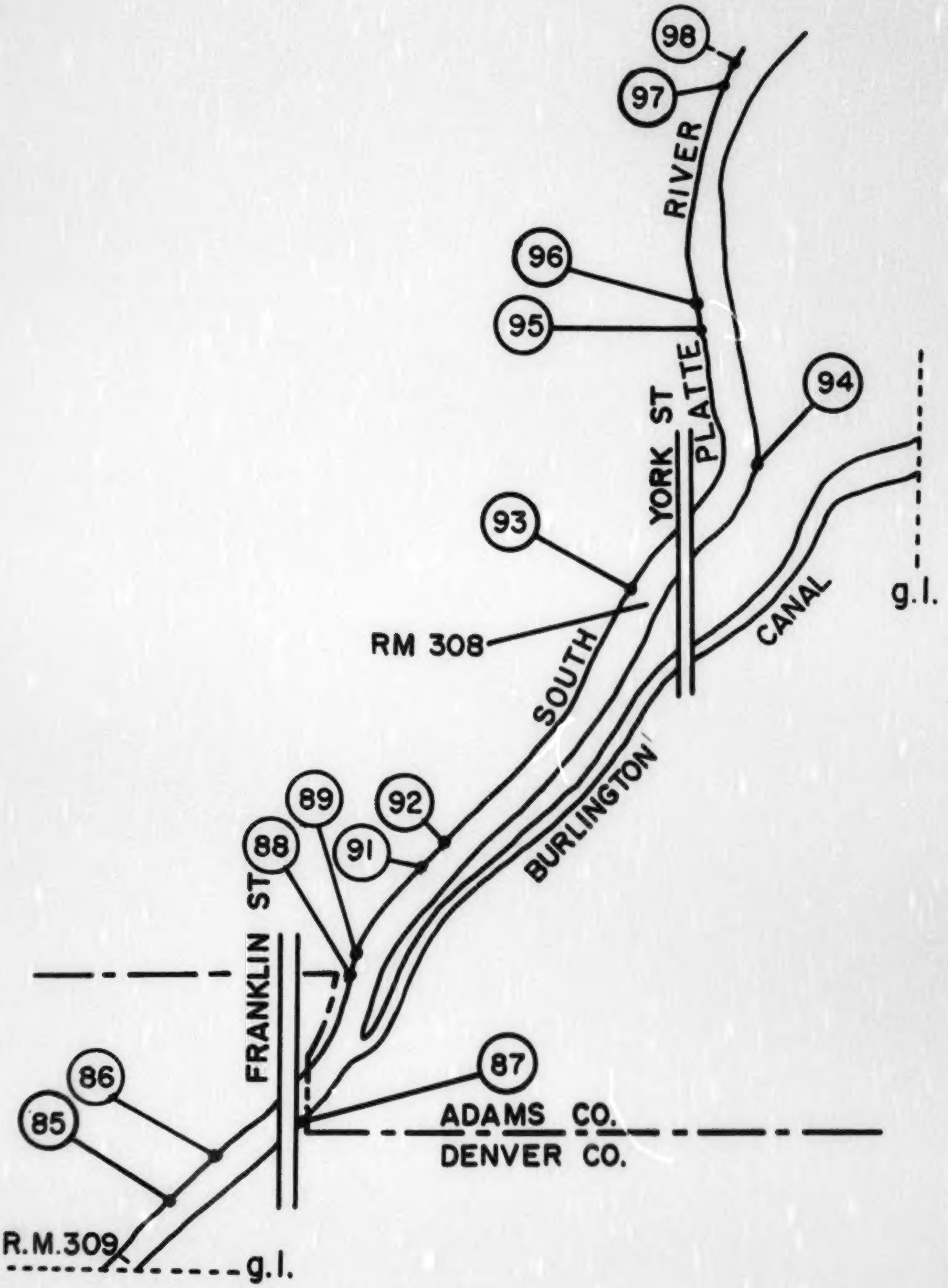
Area D, Figure 1


g.l.
51
50
RM 1
COLFAX AVE.
CHERRY
13TH AVE.
49
11TH AVE.
48
RM 2
8TH AVE.
CREEK
4TH AVE.
47

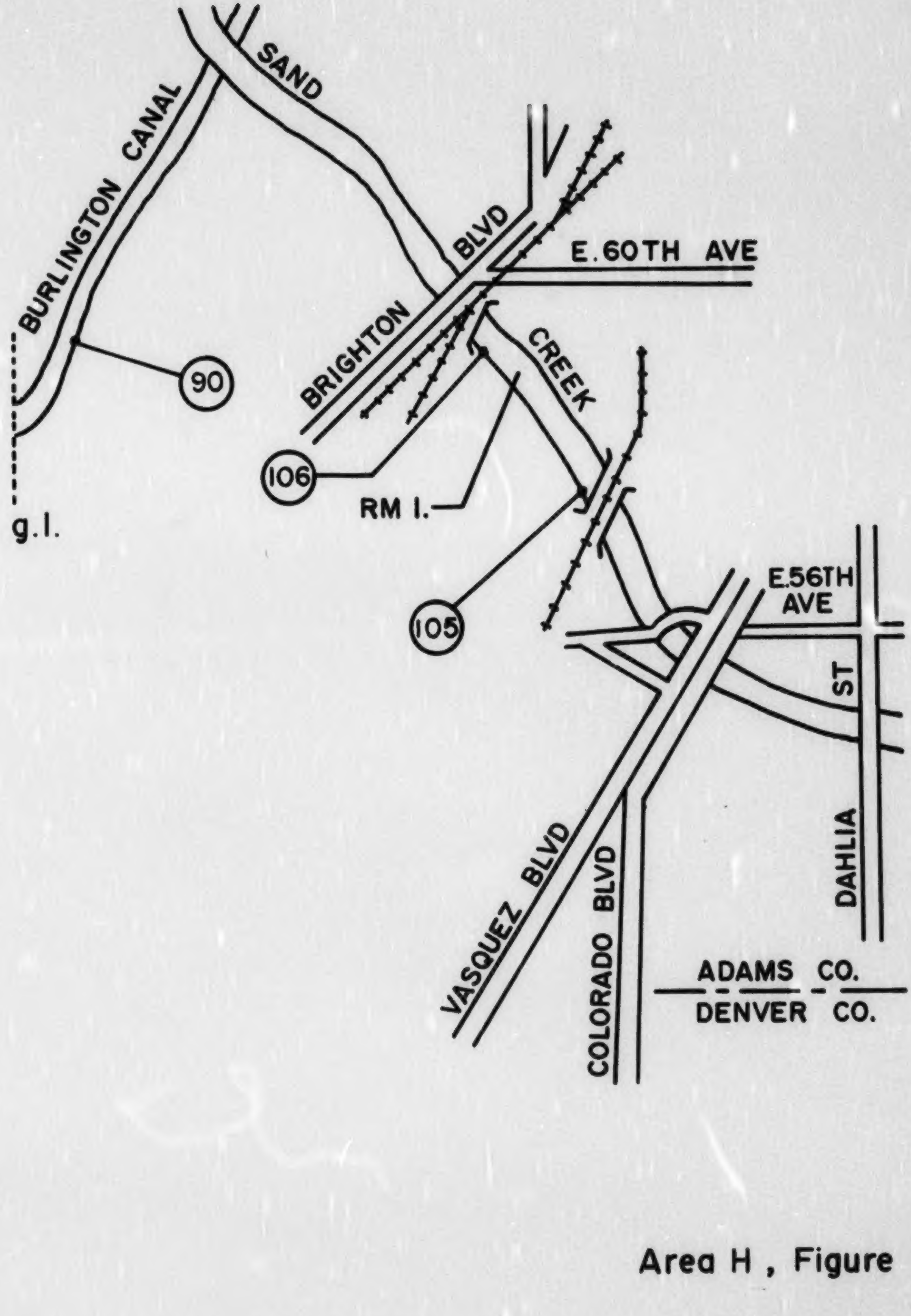
Area E, Figure 1


g.l.
84
81
83
80
82
78
79
77
76
74
75
73
ST
46 TH AVE
WASHINGTON
72
RM 310
71
69
38TH AVE
68
R.
67
SOUTH-PLATTE
70
66
62
65
BRIGHTON BLVD
RM 311
31 ST
63
61
ST
g.l.
64

Area F, Figure 1


98
97
RIVER
96
95
PLATTE
94
YORK ST
93
RM 308
SOUTH
CANAL
g.l.
BURLINGTON
89
92
88
91
FRANKLIN ST
86
87
85
ADAMS CO.
DENVER CO.
R.M.309
g.l.

Area G, Figure I


SAND
BURLINGTON CANAL
BRIGHTON BLVD
E. 60TH AVE
CREEK
90
106
RM I.
105
g.l.
E.56TH AVE
ST
DAHLIA
VASQUEZ BLVD
COLORADO BLVD
ADAMS CO.
DENVER CO.

Area H , Figure 1

Appendix A Table I

WASTE LOADING TO BASIN STREAMS
BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES

Map Ident. No.	Source	River Mile	Discharged to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA												
1.	Ditch	334.9/2.0	Brush Creek	Trickling filter plant for domestic wastes. Chemical precipitation and settling for process wastes.	1.04	20	32	170	280	---	---	0.6	Discharge from Martin Co. 1.2 lbs/day total Cr. Sampling station in Brush Creek reflects all wastes discharged.
2.	Ditch	329.3/6.3	Plum Creek	None	0.81	3	6	20	40	---	---	---	Discharge from Du Pont de Nemours Co. Nitrate 51 mg/l.
3.	Littleton Municipal STP	323.5	S. Platte	Secondary, without chlorination.	2.6	43	38	720	78	5.4×10^6	---	---	
4.	Evergreen Municipal STP	320.9/19.3	Bear Creek	Secondary, without secondary settling. Existing chlorination facilities not used.	0.07	80	86	40	50	3.3×10^6	---	---	
5.	Federal Correctional Institution STP	320.9/5.5	Bear Creek	Secondary, without secondary settling or chlorination.	0.06	165	80	50	40	2.6×10^6	---	---	
6.	72" Outfall	319.8	S. Platte	None	0.24	12	4	20	10	33,000	---	0.4	
7.	24" Outfall	319.9	S. Platte	None	0.02	---	---	---	---	---	---	---	Total solids 55,740 mg/l. Total volatile solids 3710 mg/l. Settleable solids 12 ml/l. COD 555 mg/l. Possibly Robinson Brick & Tile Co.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharged to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
8.	Englewood Municipal STP	319.7	S. Platte	Secondary, with chlorination	4.5	48	43	1350	1460	$3.7x10^6$	---	---	
9.	18" Outfall	319.7	S. Platte	None	1.01	3	43	30	360	---	---	0.2	Discharge from Arapahoe plant, Public Service Co.
10.	Sanderson Gulch	317.4	S. Platte	None	2.95	21	20	520	490	---	---	3.0	
11.	10" Outfall	317.3	S. Platte	None	0.05	510	1540	210	640	---	107	---	Possibly Navajo Freight Lines.
12.	4x10' Outfall	317.2	S. Platte	None	0.47	8	20	30	80	---	0.5		
13.	4x6' Outfall Mississippi Ave.	317.0	S. Platte	None	2.20	22	194	410	3580	---	---	---	Primary sources are Gates Rubber Co. and Samsonite Corp. Gates discharges average 100 lbs of oil daily. Samsonite discharges average 49 lb CN daily.
14.	36" Outfall	316.6	S. Platte	None	0.02	2	2	---	---	---	1	---	
15.	36" Outfall	316.5	S. Platte	None	0.08	29	227	20	160	---	---	---	Settleable solids 1.8 ml/l.
16.	52" Outfall Exposition Ave.	316.4	S. Platte	None	0.22	35	2060	60	3780	---	---	---	Settleable solids 7.5 ml/l.
17.	30" Outfall	316.0	S. Platte	None	0.07	6	9	---	---	---	16		Possibly Denver Tramway Co.
18.	42" Outfall	315.6	S. Platte	None	0.20	450	88	750	150	---	26	---	

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharged to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
19.	10" Outfall	315.3	S. Platte	None	0.84	8	20	60	140	---	---	1.8	Discharge from General Chemical Div. Cooling water--all process water obtained from S. Platte River.
20.	12" Outfall	315.3	S. Platte	None	0.49	7	19	30	80	---	---	1.8	See No. 19.
21.	12" Outfall	315.2	S. Platte	None	0.03	6	19	---	---	---	---	1.5	See No. 19.
22.	8" Outfall	315.1	S. Platte	None	0.26	16	15	40	30	---	---	1.9	See No. 19.
23.	10" Outfall	315.1	S. Platte	None	0.29	13	23	30	60	---	---	1.6	See No. 19.
24.	36" Outfall	314.7	S. Platte	None	0.02	10	7	---	---	---	---	0.6	
25.	3" Outfall	314.5	S. Platte	None	0.01	6	62	---	---	---	---	0.3	
26.	72" Outfall	314.4	S. Platte	Oil separation at D&RG Railroad	0.21	670	410	1170	720	---	1330	2.4	Principal source of oil is D&RG Railroad. One grab sample not included in oil ave. was 555,000 MG/L.
27.	S. Lakewood San. Dist. Municipal STP	314.1	S. Platte	Secondary, with chlorination	0.55	52	76	175	310	160,000	---	---	
28.	18x12' Outfall Weir Gulch	314.1	S. Platte	None	1.14	6	4	60	40	---	---	0.1	
29.	18" Outfall	314.1	S. Platte	None	0.01	22	169	---	15	---	14	---	
30.	30" Outfall	313.7	S. Platte	Settling pond.	1.15	10	267	91	2560	---	---	0.5	Discharge from Zuni plant, Public Service Co. Fly-ash lagoon only.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharged to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
METROPOLITAN DENVER AREA (Continued)													
31.	2x4' Outfall	313.7	S. Platte	None	1.44	9	44	110	530	---	---	0.8	Discharge from Zuni plant, Public Service Co. -- cooling water -- principal source of process water is South Platte River.
32.	10" Outfall	313.7	S. Platte	None	0.03	10	98	---	20	---	---	0.9	Discharge from Zuni plant, Public Service Co. -- overflow from softening process -- backwash twice each day of 600 gallons contains high amounts of lime.
33.	50x12' Outfall Dry Gulch	313.5	S. Platte	None	1.90	4	66	80	1380	---	---	0.4	
34.	16" Outfall	313.5	S. Platte	None	0.12	119	461	120	460	---	---	5.0	
35.	16" Outfall	313.5	S. Platte	None	0.23	430	2800	820	5360	---	508	---	Possibly National Oil Corp.
36.	48" Outfall	313.5	S. Platte	None	0.13	8	10	---	---	---	---	1.6	
37.	18" Outfall	313.1	S. Platte	None	0.13	450	---	490	---	---	---	0.3	
38.	5x4' Outfall	313.0	S. Platte	None	0.10	44	14	40	10	---	5.0		
39.	8" Outfall	312.9	S. Platte	None	<0.01	272	164	---	---	---	127	---	Discharge from C&S Railroad.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
40.	24" Outfall	312.8	S. Platte	Oil separation	<0.01	214	566	---	---	13,000	497	0.2	Settleable solids 3.8 ml/l. Discharge from C&S Railroad.
41.	Wooden Outfall	312.7	S. Platte	None	0.01	3	63	---	---	1,100	8	---	Discharge from C&S Railroad.
42.	6x8" Wood Outfall	312.7	S. Platte	None	<0.01	38	294	---	---	---	22	---	Settleable solids 1.7 ml/l. Discharge from C&S Railroad.
43.	6x4' Outfall	312.7	S. Platte	None	0.10	160	86	140	70	---	---	---	
44.	30" Outfall S. Colorado Blvd.	312.3/5.7	Cherry Creek	None	0.07	30	280	20	160	11,000	---	4.8	
45.	48" Outfall Marion St.	312.3/3.1	Cherry Creek	None	0.05	4	20	---	10	35,000	---	0.1	
46.	54" Outfall 3rd Ave.	312.3/2.7	Cherry Creek	None	0.32	3	4	---	10	---	---	---	
47.	24" Outfall 4th Ave.	312.3/2.6	Cherry Creek	None	0.01	30	409	---	30	---	9	---	
48.	18" Outfall 10th Ave.	312.3/1.8	Cherry Creek	None	<0.01	66	564	---	20	---	9	---	
49.	12" Outfall 12th Ave.	312.3/1.5	Cherry Creek	None	0.03	1050	2100	260	530	170,000	25	16.1	Settleable solids 1.5 ml/l.
50.	30" Outfall Stout St.	312.3/1.2	Cherry Creek	None	0.04	3	15	---	---	1,700	---	0.1	

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
51.	36" Outfall Stout St.	312.3/1.2	Cherry Creek	None	0.09	97	878	70	660	3,300	---	6.7	Settleable solids 9.0 ml/1.
52.	30" Outfall Curtis St.	312.3/0.8	Cherry Creek	None	0.03	155	41	40	10	9,500	16	65	
53.	48" Outfall	312.3/0.2	Cherry Creek	None	0.06	21	315	10	160	28,000	---	0.4	Settleable solids 39.0 ml/1.
54.	3x5' Outfall	311.9	S. Platte	None	2.93	9	56	220	1370	130,000	---	1.1	
55.	4x5' Outfall	311.8	S. Platte	None	0.23	17	31	30	60	---	---	3.4	
56.	24" Outfall	311.8	S. Platte	None	<0.01	90	82	---	---	---	---	11.0	
57.	6' Outfall	311.7	S. Platte	None	0.24	25	558	50	1120	---	---	0.9	
58.	24" Outfall	311.4	S. Platte	None	0.02	142	96	20	20	130,000	---	14	Discharge from CB&Q Railroad.
59.	8" Outfall	311.3	S. Platte	None	0.01	69	61	---	---	---	---	1.7	
60.	8" Outfall	311.2	S. Platte	Oil Separation	0.40	381	156	1270	520	---	143	2.0	Flow value a result of 24-hour gaging. Discharge from CB&Q Railroad.
61.	30" Outfall	311.1	S. Platte	None	0.07	21	712	10	420	22,000	---	2.6	Possibly Digby Trucking. Settleable solids 11.0 ml/1.
62.	10" Outfall	310.8	S. Platte	None	0.02	125	343	20	60	---	54	---	Possibly Ryder Truck Rental.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
63.	6" Outfall	310.8	S. Platte	None	0.01	410	1070	30	90	---	98	---	Possibly Ryder Truck Rental. Settleable solids 2.0 ml/l.
64.	7" Outfall	310.8	S. Platte	None	0.14	126	1030	150	1200	---	85	4.0	
65.	10" Outfall	310.8	S. Platte	None	0.22	1	2	---	---	6.8	---	0.4	
66.	12" Outfall	310.6	S. Platte	None	0.02	1040	1269	170	1270	---	4783	24	Settleable solids 8.0 ml/l. Possibly Ringsby Truck Line.
67.	4" Outfall	310.5	S. Platte	None	<0.01	150	192	---	10	28,000	33	4.9	Possibly Yellow Cab Co.
68.	8" Outfall	310.5	S. Platte	None	0.01	1314	804	110	70	---	1253	---	Settleable solids 7.0 ml/l. Possibly Yellow Cab Co.
69.	24" Outfall	310.4	S. Platte	None	0.10	295	126	250	110	---	---	---	Possibly Red Ball Express.
70.	84" Outfall 36th St. & Arkins	310.3	S. Platte	None	1.30	329	126	3560	1370	230,000	---	1.0	Settleable solids 3.6 ml/l.
71.	Two 6x6' Outfalls 38th Ave.	310.0	S. Platte	None	0.28	46	116	110	270	---	---	0.8	
72.	36" Outfall	309.7	S. Platte	None	0.07	6	15	---	10	---	---	0.2	
73.	4" Outfall	309.6	S. Platte	None	0.03	2	21	---	---	---	---	0.4	

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
74.	3x6' Outfall	309.6	S. Platte	None	2.48	319	324	6,600	6,700	130,000,000	---	6.7	Periodic discharge of raw sewage from Denver sanitary sewer overflow. Settleable solids 10 ml/1.
75.	72" Outfall	309.5	S. Platte	None	0.09	15	0	10	---	---	---	0.2	
76.	30" Outfall	309.5	S. Platte	None	0.10	167	137	140	110	---	---	2.9	
77.	10" Outfall	309.5	S. Platte	None	0.04	32	49	11	16	---	---	---	Grease -- 3 lbs/day discharges from Armour Co.
78.	Two 12" Outfalls	309.5	S. Platte	None	0.29	9	8	22	19	---	---	---	Grease -- 43 lbs/day discharges from Armour Co.
79.	18" Outfall	309.5	S. Platte	None	0.09	62	112	50	80	---	---	---	Discharge from Denver Union Stockyards.
80.	6" Outfall	309.5	S. Platte	None	0.04	5	6	---	---	---	---	---	Discharge from Wilson Co. -- cooling water waste -- grease 2 mg/1.
81.	12" Outfall	309.4	S. Platte	None	0.08	13	16	10	10	---	---	---	Discharge from Capitol Packing Co.
82.	24" Outfall	309.4	S. Platte	None	1.80	93	84	1,400	1,260	---	---	---	Discharge from Denver Union Stockyards.
83.	24" Outfall	309.3	S. Platte	None	0.08	50	21	30	10	---	---	---	Discharge from Denver Union Stockyards.
84.	24" Outfall	309.1	S. Platte	None	0.46	4	15	10	60	---	---	---	Discharge from Denver Union Stockyards.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
85.	42" Outfall	308.9	S. Platte	None	0.80	92	134	610	890	79,000	---	1.8	
86.	Denver Northside Municipal STP	308.8	S. Platte	Primary with aeration and chlorination	72.53	174	96	105,000	57,000	30,000	---	---	Will cease all discharge in Jan. 1967 upon MDSDD#1 operation.
87.	24" Outfall Franklin St.	308.7	S. Platte	None	0.52	227	192	980	830	790	---	3.2	
88.	12" Outfall	308.6	S. Platte	None	<0.01	130	1354	---	---	13,000,000	---	2.5	Settleable solids 8.0 ml/l. Discharge from United Fryer Stillman Co.
89.	8" Outfall	308.6	S. Platte	None	0.02	3	12	---	---	1.8	---	0.1	Possibly from United Fryer Stillman Co.
90.	12" Outfall	308.6/1.1	Burlington Ditch	Steam-stripper--bio-oxidation process--oil separation--settling.	0.35	26	21	80	60	---	7.0	---	Phenol 0.8 lb/day total CN^- 2.6 lb/day. Discharge from Continental Oil Co.
91.	24" Outfall	308.5	S. Platte	None	0.05	220	91	90	40	7,000,000	---	5.2	
92.	16" Outfall	308.5	S. Platte	None	0.06	2550	2550	1,280	1,280	3,300,000	---	4.8	Possibly Chuck's Truck Wash.
93.	10" Outfall	308.0	S. Platte	Grease traps	0.35	215	140	630	410	---	---	---	Settleable solids 1.2 ml/l. Discharge from Capitol Rendering Co.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
94.	24" Outfall	307.8	S. Platte	Fiber removal for return to process.	0.70	740	2260	4320	13,200	---	19.0	---	Settleable solids 287 ml/l. SO_4 675 mg/l. Discharge from Packaging Corp. of America. All discharge will cease in Jan. 1967 upon MDSDD#1 operation.
95.	18" Outfall	307.6	S. Platte	Settling and skimming for grease removal--vibrating screens for paunch manure removal--connection to N. Washington District sanitary sewers.	0.04	92	416	30	140	220,000	---	---	Discharge from Litvak Packing Co. Grease 29 lb/day. Settleable solids 0.7 ml/l.
96.	8" Outfall	307.6	S. Platte	See No. 95	<0.01	2678	975	---	---	$2x10^6$	---	---	Discharge from Litvak Packing. Grease 1983 mg/l Settleable solids 1.6 ml/l.
97.	42" Outfall	307.3	S. Platte	None	2.16	7	60	130	1,080	---	---	1.1	Discharge from Cherokee plant, Public Service Co. --cooling water--principal source of process water is South Platte River.
98.	24" Outfall	307.3	S. Platte	None	0.08	13	142	10	100	170,000	---	0.6	Same as No. 97

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
99.	Buckley Airfield STP	306.8/11.9	Sand Creek	Secondary, without chlorination.	0.05	23	40	10	20	79,000	---	---	
100.	Fitzsimons Army Hospital STP	306.8/6.9	Sand Creek	Secondary, with chlorination.	0.47	27	36	70	150	20,000	---	---	
101.	Aurora (Westerly) Municipal STP	306.8/5.5	Sand Creek	Secondary, with chlorination.	3.10	64	77	1370	2,030	$4.2x10^6$	---	---	
102.	Aurora (Sand) Municipal STP	306.8/6.8	Sand Creek	Secondary, with chlorination.	0.66	20	42	100	250	18	---	---	
103.	Two 24" Outfalls	306.8/4.3	Sand Creek	Several oil sumps in parallel--all domestic wastes to Denver Sanitary sewers.	0.10	395	72	330	60	---	15	44	Phenols 3 lb/day. Discharge from maintenance and cleaning activities at Stapleton Airfield.
104.	Denver Eastside Municipal STP	306.8/4.2	Sand Creek	Primary, with chlorination.	1.40	205	85	2050	1,040	140,000	---	---	Will cease all discharge in Jan. 1967 upon MDSDD#1 operation.
105.	Ditch	306.8/1.1	Sand Creek	Oil separators and settling.	0.45	20	9	80	30	---	3.5	---	Phenols 2.6 lb/day. Discharge from Empire Oil Co.
106.	6" Outfall	306.8/0.9	Sand Creek	Oil separators and phenol stripping.	0.61	32	13	160	70	---	3.0	---	Phenols 8.7 lb/day. Discharge from Tenneco Oil Co.
107.	N. Washington San. Dist. Municipal STP	305.5	S. Platte	Secondary, without secondary settling and chlorination.	1.50	435	360	4460	3,900	$45x10^6$	---	---	Member MDSDD#1.

Appendix A Table 1

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
108.	Ditch	305.5/16.1	Clear Creek	Settling pond.	<0.01	10	24	---	---	1.8	---	0.9	Discharge from Colo. Sch. of Mines Research Foundation.
109.	Ditch	305.5/15.8	Clear Creek	None	0.03	92	2596	20	650	---	---	---	Settleable solids 18.8 ml/l. Discharge from floor drains at Coors Porcelain Co.
110.	Adolph Coors Co. Industrial and Municipal STP (Golden)	305.5/15.5	Clear Creek	Secondary, with chlorination.	2.7	30	20	640	480	790,000	---	---	
111.	N.W. Lakewood San. Dist. Municipal STP	305.5/10.2	Clear Creek	Primary, without chlorination.	1.90	215	126	2780	2,010	6.6×10^6	---	---	All discharge will cease Jan. 1967 upon MDSDD#1 operation.
112.	Fruitdale San. Dist. STP	305.5/10.0	Clear Creek	Primary, without chlorination.	0.20	110	75	200	110	59×10^6	---	---	All discharge will cease Jan. 1967 upon MDSDD#1 operation.
113.	Wheatridge Municipal STP	305.5/7.5	Clear Creek	Secondary, with chlorination.	1.80	95	64	1210	980	1.7×10^6	---	---	Member MDSDD#1.
114.	Clear Creek San. Dist. Municipal STP	305.5/7.0	Clear Creek	Secondary, with chlorination facilities not in use.	1.49	285	117	1690	550	8.3×10^6	---	---	
115.	Ditch	305.5/6.4	Clear Creek	None	1.30	9	4	80	40	140,000	---	0.7	

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
116.	Arvada Municipal STP	305.5/6.2	Clear Creek	Secondary, without chlorination.	3.50	210	209	4760	5,760	$7.6x10^6$	---	---	Portion of raw sewage bypassed. Member MDSDD#1.
117.	54" Outfall	305.5/6.2	Clear Creek	None	0.06	61	10	30	---	$33x10^6$	---	3.4	
118.	Ditch west of Federal	305.5/4.5	Clear Creek	None	0.16	6750	48	9000	60	79,000	96	14	
119.	Westminster Municipal STP	305.5/3.6	Clear Creek	Secondary, with chlorination facilities not in use. Only primary settling now provided.	1.30	335	196	3030	2,160	$37x10^6$	---	---	Member MDSDD#1.
120.	Baker San. Dist. Municipal STP	305.5/3.0	Clear Creek	Secondary, without chlorination.	1.50	150	105	1650	1,390	$9.7x10^6$	---	---	Portion of raw sewage bypassed. Member MDSDD#1.
121.	Thornton Municipal STP	303.5	S. Platte	Secondary, with chlorination.	2.60	205	212	3540	4,460	$36x10^6$	---	---	Member MDSDD#1.
122.	S. Adams San. Dist. Municipal STP	301.2	S. Platte	Secondary, with chlorination.	1.50	26	55	260	640	5,200	---	---	
123.	Ditch	293.5	S. Platte	Settling pond (12 acres).	0.43	150	276	620	1,130	$2x10^6$	---	---	Discharge from Gates Cyclo Co.
124.	Brighton Municipal STP	289.5	S. Platte	Secondary, with chlorination.	0.65	12	34	50	170	520	---	---	
125.	Ditch	289.4	S. Platte	None	0.26	196	173	430	380	---	---	---	Discharge from canning operations at Kuner Empson Co.

Appendix A Table I

WASTE LOADING TO BASIN STREAMS BY DIRECT DISCHARGE FROM INDUSTRIAL AND MUNICIPAL SOURCES (Continued)

Map Ident. No.	Source	River Mile	Discharge to	Treatment Provided	Est. Flow MGD	BOD MG/L	TSS MG/L	Est. BOD Lbs/Day	Est. TSS Lbs/Day	Total Coliform MPN/100 ml	Oil MG/L	ABS MG/L	Remarks
	METROPOLITAN DENVER AREA (Continued)												
126.	18" Outfall	288.6/0.4	McCann Ditch (flows into S. Platte during sugar beet campaign).	None	0.05	18	126	10	50	---	---	---	Discharge from sauerkraut processing at Kuner Empson Co.

APPENDIX B

Meat Industry Waste Study

SUMMARY

The Project conducted a study during the Fall of 1964 to determine the degree of treatment and disposal of wastes from the meat industry in the Denver Metropolitan area. Municipal waste treatment plants, the Omaha, Nebraska plant particularly, have experienced considerable difficulty in handling this type of waste. The objective of the study was to determine the amounts of paunch content wastes, the in-plant treatment facilities provided by the packinghouses and the method of final disposal. Also, the amounts and disposal of manure from holding pens, the in-plant facilities for grease removal and the methods of disposal for blood, grease and renderable products were investigated. The information obtained from interviews and visual observations at the meat industry plants is tabulated in five tables.

These data indicate that about half of the paunch content wastes are removed by in-plant treatment and used as fertilizer. The remainder, about 60 tons, are discharged to the sanitary sewers. The majority of manure from holding pens is collected and used as fertilizer. However, portions of this manure are discharged to sanitary sewers and also to the South Platte River. The majority of meat industry plants provide facilities for in-plant grease removal although these facilities do not appear adequate in all cases.

CONCLUSIONS

1. It is estimated that 125 tons of paunch contents are handled each operating day at the 13 slaughterhouses in the Denver Metropolitan area. Of the total amount, it is estimated that 60 tons are discharged to sanitary sewers. The Denver Northside plant receives about 56 tons and the North Washington District plant receives 4 tons. The remainder of the paunch contents are removed by in-plant treatment at the slaughterhouses and collected and utilized by individual farmers and fertilizer operations.

2. It is estimated that 200 tons of manure are obtained daily from holding pens in the Denver Metropolitan area. This material is collected in trucks and transported to fertilizer plants. It is estimated that one ton of manure is discharged to the South Platte River daily via surface drains predominantly from the Denver Union Stockyards.

3. The Altberger Co. (No. Washington Sanitary District) discharges all process wastes, including blood, offal, paunch contents and grease to the sanitary sewers without treatment.

4. Other known wastes from the packing industry are discharged to the sanitary sewers, with the exception of those conveyed directly to the South Platte River noted below:

    1. Armour and Company, grease and holding pen drainage.
    2. Capitol Rendering Co., rendering wastes.

3. Denver Union Stockyards, holding pen drainage.

4. Litvak Packing Co., rendering wastes.

5. United-Fryer-Stillman Co., miscellaneous packing wastes.

5. Additional in-plant treatment facilities will be necessary in certain meat industry plants in order to comply with present MDSDD#1 restrictions concerning the discharge of paunch contents and grease.

DESCRIPTION

In the meat industry, packinghouse operations include slaughtering, processing and rendering. Slaughterhouses provide facilities for trimming, washing and cooling of carcasses, in addition to the killing operation. Processing plants receive carcasses and provide meat cutting, curing, smoking, pickling, sausage manufacturing and meat canning operations. Rendering consists of cooking edible and non-edible materials in order to obtain a variety of by-products.

In the Denver Metropolitan area, the meat industry essentially consists of 3 packinghouses, 10 slaughterhouses some of which also render or process, 2 rendering plants, 4 processing plants, and 1 blood dehydrating plant. In addition, the principal market and holding area serving this industry is the Denver Union Stockyards.

The major waste products from meat packing operations include paunch contents, grease, fat particles, blood and manure obtained from holding pens. These wastes are somewhat similar to domestic wastes, however they are characterized by much higher values for biochemical oxygen demand and solids, and contain large amounts of grease.

The paunch contents are the partially digested feed and manure present in an animal's stomach at the time it is slaughtered. In cattle, the wet weight of the paunch contents is reported to range normally from 55 to 70 pounds per 1000 pounds of live weight (1). If the animal is not fed for 24 hours prior to slaughter, the weight of the paunch contents will be reduced to about one-third of the values expressed above. The value for wet weight of paunch contents used in this report is based upon actual tests conducted in Denver. These tests performed by plant personnel at the Cudahy Packing Co., consisted of weighing several freshly-removed paunches from both cattle and hogs. The average wet weight for beef was 60 pounds per 1000 pounds of live weight; and for hogs 4 pounds per 250 pounds of live weight.

The total wet weight of excreta from live animals is approximately proportional to their weight. It has been estimated that daily contributions of manure, per 1000 pounds live weight are: 64 pounds for cattle, 70 pounds for hogs and 63 pounds for sheep (2). These values have been used for the purposes of this report.

PRESENTATION OF DATA

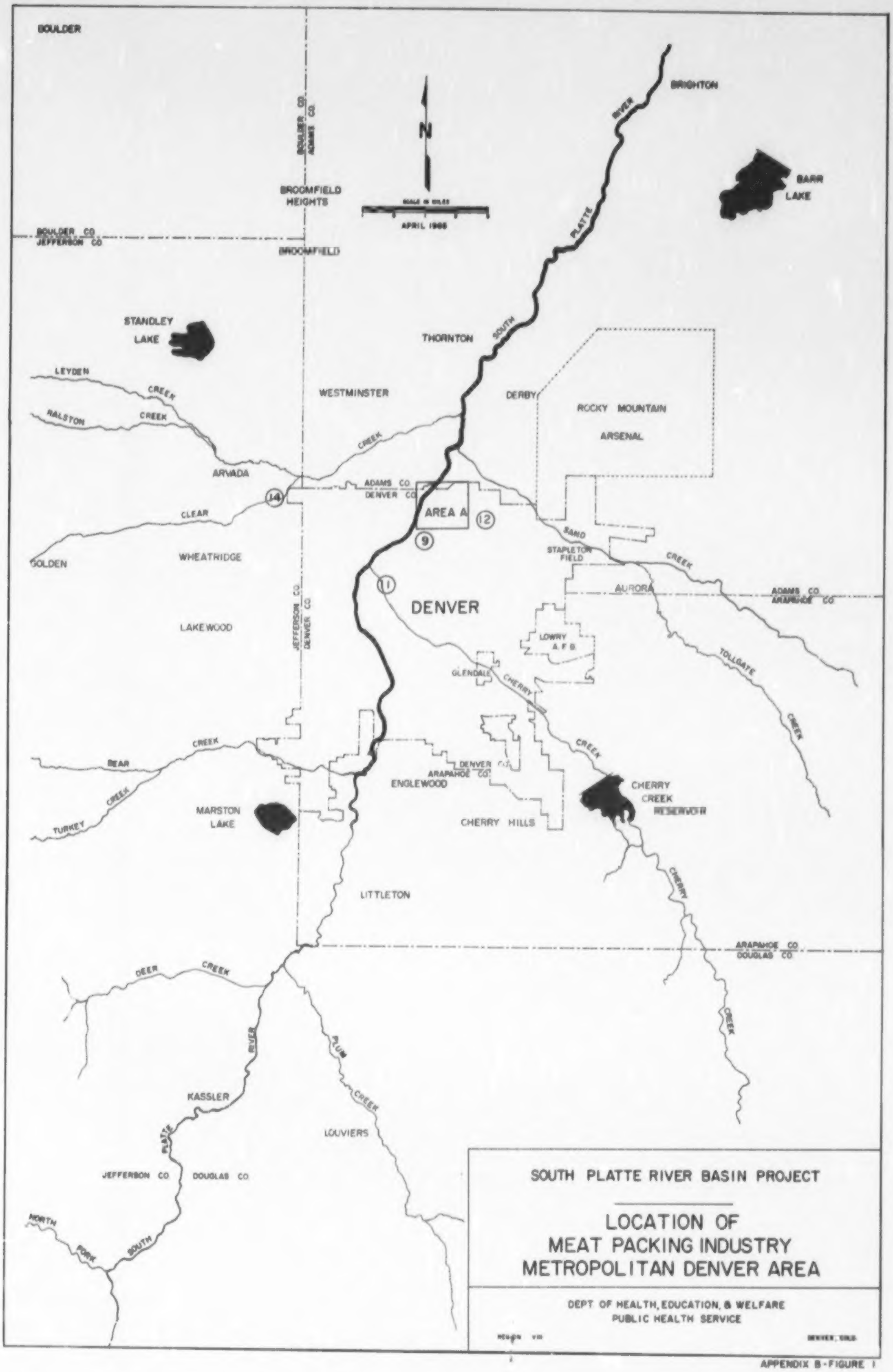
Project data for the meat industry in the Denver Metropolitan area are shown in Tables I through V. These data are based upon information obtained from officials of the industry and visual observations during plant visits. In Table I and Figure 1, the location of meat industry facilities is given. This table also describes the type of facility and the sanitary sewer system to which the industry is connected.

In Table II, overall loading from paunch contents, in-plant treatment facilities and disposal of solids are given. In Table III, size and type of holding pens and disposal of manure and drinking water drains are shown. Table IV, contains information on rendering operations and ultimate waste disposal. In Table V, in-plant grease removal facilities and final waste disposal are shown.

TABLE I

GENERAL INFORMATION FOR THE MEAT PACKING INDUSTRY DENVER METROPOLITAN AREA

Map Identification No.	Industry	Type of Meat Industry	Sewer District
1	Denver Union Stockyards	Stockyards	Denver
2	Swift	Packing	Denver
3	Cudahy	Packing	Denver
4	Pepper	Slaughtering	Denver
5	Armour	Slaughtering & Processing	Denver
6	Capitol Packing	Slaughtering & Rendering	Denver
7	Wilson	Slaughtering	Denver
8	United-Fryer-Stillman	Packing	Denver
9	National Foods (Denver)	Processing	Denver
10	National Foods	Slaughtering & Rendering	No. Washington
11	Mapelli-Lindner-Sigman	Processing	Denver
12	Safeway	Processing	Denver
13	Litvak	Slaughtering & Rendering	No. Washington
14	Sigman	Slaughtering & Processing	Clear Creek Valley
15	Altberger	Slaughtering	No. Washington
16	Bell Packing Co.	Slaughtering	No. Washington
17	Denver Boneless Beef	Processing	No. Washington
18	Adams Packing	Slaughtering	Denver
19	Denver Rendering	Rendering	Denver
20	Capitol Rendering	Rendering	No. Washington
21	Meinerz Blood Dehydrating	Blood Processing	Denver



BOULDER
BOULDER CO
ADAMS CO
BROOMFIELD HEIGHTS
N
SCALE IN MILES
APRIL 1966
BRIGHTON
BARR LAKE
BOULDER CO
JEFFERSON CO
BROOMFIELD
SOUTH PLATTE RIVER
STANDLEY LAKE
THORNTON
ROCKY MOUNTAIN ARSENAL
DERBY
LEYDEN CREEK
RALSTON CREEK
WESTMINSTER
CREEK
ARVADA
14
ADAMS CO
DENVER CO
AREA A
12
9
CLEAR
GOLDEN
WHEATRIDGE
SAND CREEK
STAPLETON FIELD
11
AURORA
ADAMS CO
ARAPAHOE CO
DENVER
JEFFERSON CO
DENVER CO
LAKEWOOD
LOWRY A.F.B.
GLENDALE
CHERRY CREEK
TOLLGATE CREEK
BEAR CREEK
TURKEY CREEK
DENVER CO
ARAPAHOE CO
ENGLEWOOD
CHERRY CREEK RESERVOIR
MARSTON LAKE
CHERRY HILLS
CHERRY CREEK
LITTLETON
ARAPAHOE CO
DOUGLAS CO
DEER CREEK
PLUM CREEK
KASSLER
LOUVIERS
SOUTH PLATTE RIVER
JEFFERSON CO
DOUGLAS CO
NORTH FORK

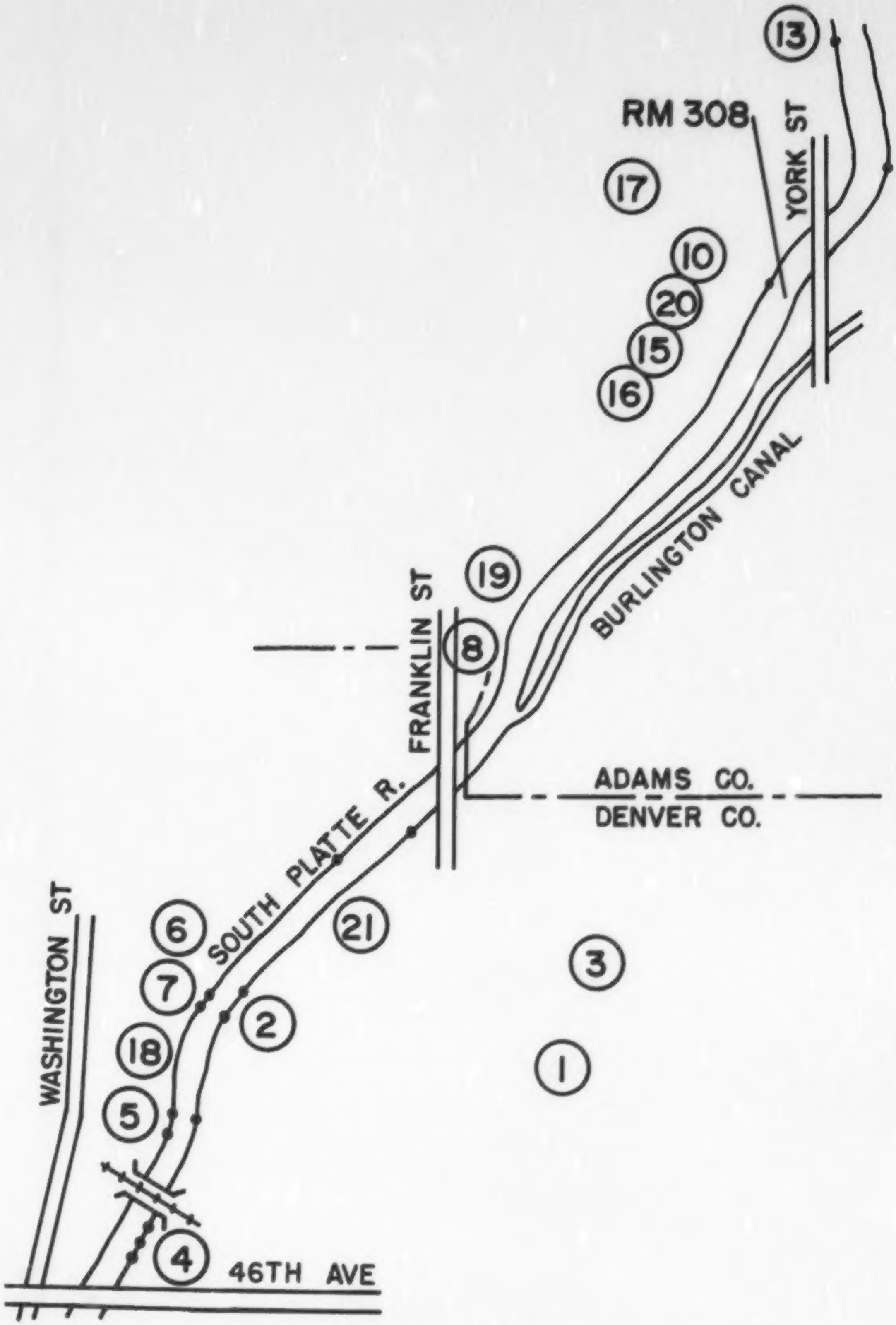
SOUTH PLATTE RIVER BASIN PROJECT

LOCATION OF MEAT PACKING INDUSTRY METROPOLITAN DENVER AREA

DEPT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

REGION VIII
DENVER, COLO.

APPENDIX B-FIGURE 1



13
RM 308
YORK ST
17
10
20
15
16
BURLINGTON CANAL
19
FRANKLIN ST
8
ADAMS CO.
DENVER CO.
SOUTH PLATTE R.
WASHINGTON ST
6
21
3
7
2
18
1
5
4
46TH AVE

Area A, Figure 1

DISCUSSION

Paunch Contents

There are 13 plants performing slaughtering operations in the Denver Metropolitan area. On the basis of data summarized in Table II, it is estimated that 125 tons of paunch contents are handled by these plants each working day. The data indicate that 80 percent (100 tons) of the paunch contents receives in-plant treatment for removal of settleable solids prior to discharge to the sanitary sewers. The remaining 20 percent (25 tons) from 3 slaughterhouses is discharged to the sanitary sewers without treatment. The treatment facilities provided by 10 slaughterhouses consist of the following: 5 plants utilize screening devices, 3 plants utilize settling basins, 1 plant uses both screening and settling, and 1 plant employs chute conveyors to place the paunch contents in a truck without using a water carriage system. It is estimated under the best operating conditions that not more than 65 tons of paunch contents are removed by in-plant treatment. These solids are collected and trucked to fertilizer concerns or carried away by farmers on a pre-arranged basis. It is estimated that 60 tons of paunch contents are discharged to the sanitary sewers each working day. These data are summarized as follows:

Paunch Contents	Total Tons/Day	Removed Tons/Day	To Sanitary Sewers Tons/Day
In-plant treatment	100	65	35
No treatment	25	0	25
	125	65	60

TABLE II

PAUNCH CONTENTS
LOADING AND REMOVAL FACILITIES FOR THE MEAT PACKING INDUSTRY
DENVER METROPOLITAN AREA

Map Identification No.	Industry	Estimated Loading Before In-Plant Treatment Pounds/day	In-Plant Separation Screen	Size	Settling Facilities		Disposal of Solids Place
Plants with Removal Facilities							
2	Swift & Co.	26,400	Rotary	1/16"	None		Reudy Fertilizer[1]
3	Cudahy Packing Co.	17,200	Vibrating	20 mesh	Yes	8'x8'x6'	Reudy Fertilizer[1]
5	Armour & Co.	14,700	Rotary	1/16"	None		Reudy Fertilizer[1]
6	Capitol Packing Co.	34,600	None		Yes	6'x8'x6'	Farmers[1]
7	Wilson & Co. Inc.	57,600	None		Yes	6'x10'x4' 6'x6'x4'	Farmers[1]
10	National Foods	24,000	None		Yes	6'x6'x12'	E&H Fertilizer[2]
13	Litvak Packing Co.	3,000	Vibrating	20 mesh	None		Farmers[2]
14	Sigman	2,800	Vibrating	20 mesh	None		Farmers[3]
16	Bell Packing Co.	8,700	Dry Removal				Farmers[2]
18	Adams Packing	6,200	Stationary	1/2"	None		Reudy Fertilizer[1]
	Total	195,200					
Plants without Removal Facilities							
4	Pepper Packing Co.	13,500					All paunch wastes to Denver sanitary sewers.
8	United-Fryer-Stillman Inc.	36,000					All paunch wastes to Denver sanitary sewers.
15	Altberger	1,600					All paunch wastes to N.Washington District sanitary sewers.
	Total	51,100					

1/ Effluent from in-plant treatment discharged to Denver sanitary sewers.

2/ Effluent from in-plant treatment discharged to N. Washington District sanitary sewers.

3/ Effluent from in-plant treatment discharged to Clear Creek Valley District sanitary sewers.

The Denver Northside plant receives an estimated 56 tons and the North Washington District plant receives an estimated 4 tons. Both of these sewage treatment plants are members of Metropolitan Denver Sewage Disposal District No. 1, which has current regulations prohibiting the discharge of paunch contents (3).

Manure from Holding Pens

Based upon the 1963 kill figure in the Denver Metropolitan area for cattle, hogs and sheep (4), the weight of manure for such animals on a daily basis (2), and an average of 1½ days detention in holding pens, it is estimated that 200 tons of manure are obtained each day exclusive of feedlot operations. This manure in most instances is collected by mechanical means and used by fertilizer concerns or farmers on a pre-arranged basis. The collection and disposal of manure from holding pens of the slaughterhouses and the Denver Union Stockyards, as shown in Table III, is satisfactory except for those instances where surface drains discharge manure to the South Platte River. This action occurs at pens operated by Armour & Co., and the Denver Union Stockyards, where livestock drinking water discharges to the ground surface and enters surface drains which empty to the River. This problem is particularly significant at the Denver Union Stockyards where Project sampling data indicated a daily pollutional loading of 1500 pounds of 5-day 20°C Biochemical Oxygen Demand.

TABLE III

DISPOSAL OF HOLDING PEN MANURE FOR THE MEAT PACKING INDUSTRY DENVER METROPOLITAN AREA

Map Identi-fication No.	Industry	Holding Pens (Area in Square feet)				Disposal of Manure	Disposal of Livestock Drinking Water
		Total	Sheltered	Open	With Concrete		
1	Denver Union Stockyards	2,452,000	662,000	1,790,000	662,000	Race Ct. Co.	South Platte or San. sewers
2	Swift & Co.	20,000	3,000	18,000	18,000	Reudy Co.	San. sewers
3	Cudahy Packing Co.	1,200	0	1,200	1,200	Reudy Co.	San. sewers
4	Pepper Packing Co.	20,000	4,000	16,000	20,000	Reudy Co. & San. sewers	San. sewers
5	Armour & Co.	120,000	0	120,000	0	Denver sewers	South Platte
6	Capitol Packing Co.	14,500	0	14,500	14,500	Farmers	San. sewers
7	Wilson & Co. Inc.	35,000	0	35,000	24,000	Farmers	San. sewers
8	United-Fryer-Stillman	27,000	0	27,000	27,000	Race Ct. Co.	Ground
13	Litvak Packing Co.	44,000	6,600	37,400	6,600	Farmers	San. sewers
14	Sigman	54,000	0	54,000	5,400	Farmers	
15	Altberger	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
16	Bell Packing Co.	180,000	0	180,000	0	Reudy Co.	Ground
18	Adams Packing	20,000	2,000	18,000	2,000	Reudy Co.	San. sewers

Rendering Operations and Grease Removal

Table IV shows that the rendering operations by the meat industry in the Denver Metropolitan area consist of rendering facilities at individual packinghouses, or the collection of such material by other rendering firms. The table also shows that animal blood is either processed at individual plants or collected and shipped to Meinerz Co. All plants shown in Table V, with the exception of Adams Packing Co., Altberger Co. and Denver Rendering Co., provide grease removal facilities. Data was not obtained from 4 processing plants (National Foods, Denver; Mapelli-Lindner-Sigman; Safeway; and Denver Boneless Beef) and Meinerz Blood Dehydrating. The time of detention and the skimming facilities for grease removal are marginal in many plants on the basis of visual observations. It is apparent that excessive amounts of grease are discharged to the sanitary sewers. The Altberger Co. presently discharges all blood, grease, and offal, including paunch contents, to the North Washington District sanitary sewers without in-plant treatment.

TABLE IV

RENDERING OPERATIONS FOR THE MEAT PACKING INDUSTRY DENVER METROPOLITAN AREA

Map Identification No.	Industry	Meat & Bone Rendered at		Blood Rendered at		Disposal of Rendering Wastes
		Own Plant	Denver Rendering	Own Plant	Meinerz	
2	Swift & Co.	X		X		Denver Sanitary Sewer
3	Cudahy Packing Co.	X		X		Denver Sanitary Sewer
4	Pepper Packing Co.		X		X	To other plants
5	Armour & Co.		X		X	To other plants
6	Capitol Packing Co.	X		X		Denver Sanitary Sewer
7	Wilson & Co. Inc.		X		X	To other plants
8	United-Fryer-Stillman	X		X		Denver Sanitary Sewer and South Platte River
10	National Foods	X		X		N. Washington District Sanitary Sewer
11	Mapelli-Lindner-Sigman Ltd.[1]		X			To another plant
12	Safeway[1]		X			To another plant
13	Litvak Packing Co.	X		X		N. Washington District Sanitary Sewer and South Platte River
14	Sigman		X		X	To other plants
16	Bell Packing Co.		X		X	To other plants
17	Denver Boneless Beef[1]		X			To another plant
18	Adams Packing		X		X	To other plants
19	Denver Rendering[1]	X				Denver Sanitary Sewer
20	Capitol Rendering[1]	X				N. Washington District Sanitary Sewer and South Platte River
21	Meinerz Blood Dehydrating[2]			X		Denver Sanitary Sewer

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[1] No blood rendering.

[2] No meat and bone rendering.

TABLE V

IN-PLANT GREASE REMOVAL FACILITIES AND DISPOSAL FOR THE MEAT PACKING INDUSTRY 1/
DENVER METROPOLITAN AREA

Map Identification No.	Industry	In-Plant Grease Removal Skimming Frequency	 Size of Tank LxWxD	Final Disposal of Tank Effluent
2	Swift & Co.	Continuous	5x20x6 40x12x4	Denver Sanitary Sewers
3	Cudahy Packing Co.	1/day	30x2½x5	Denver Sanitary Sewers
4	Pepper Packing Co.	1/day	20x6x5	Denver Sanitary Sewers
5	Armour & Co.	1/day	20x12x6¼	Denver Sanitary Sewers
6	Capitol Packing Co.	1/day	5x8x5	Denver Sanitary Sewers
7	Wilson & Co. Inc.	1/day	4x40x3	Denver Sanitary Sewers
8	United-Fryer-Stillman	Continuous	15x3x2	Denver Sanitary Sewers and South Platte River
10	National Foods	Continuous	30x11x8½	N. Washington District Sanitary Sewers
13	Litvak Packing Co.	Continuous	30x10x6	N. Washington District Sanitary Sewers and South Platte River
14	Sigman	Continuous	8x10x6	Clear Creek Valley District Sanitary Sewers
15	Altberger		None	N. Washington District Sanitary Sewers
16	Bell Packing Co.	2/day	6x4x2½	Denver Sanitary Sewers
18	Adams Packing		None	Denver Sanitary Sewers
19	Denver Rendering		None	Denver Sanitary Sewers
20	Capitol Rendering	1/day	16x2x4 10x2½x4½	N. Washington District Sanitary Sewers and South Platte River

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1/ Data not available for National Foods (Denver), Mapelli-Lindner-Sigman, Safeway, Denver Boneless Beef, and Meinerz.

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